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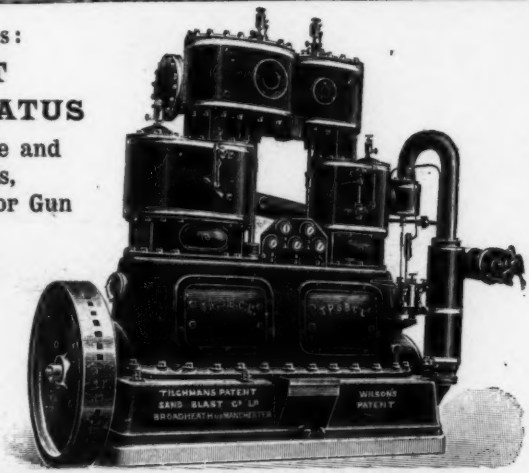

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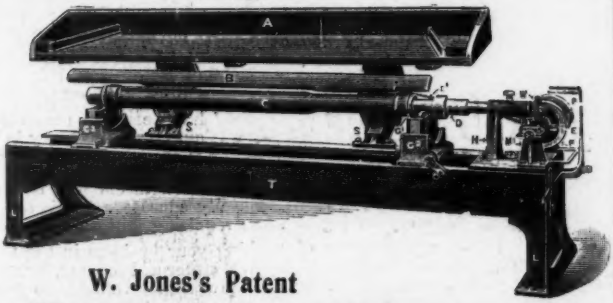

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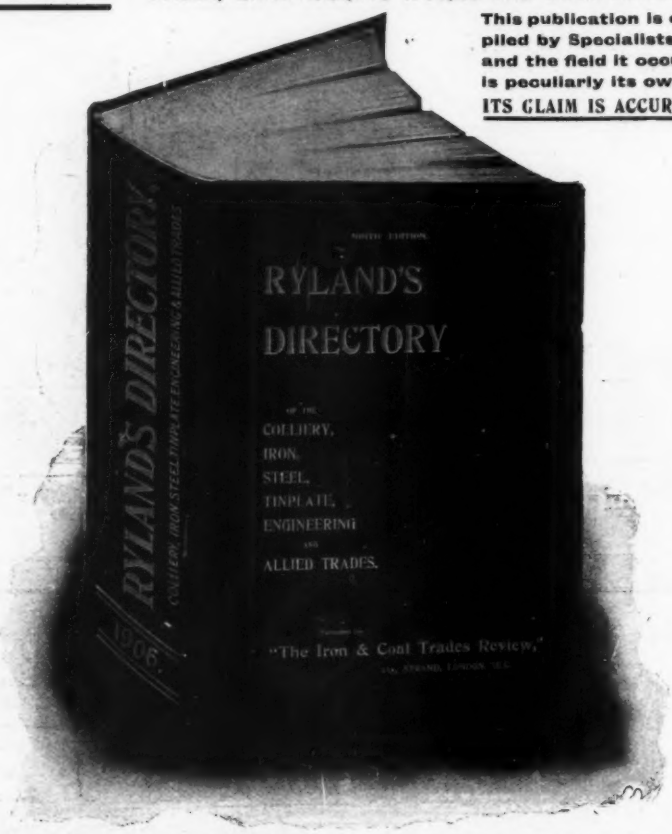

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BRITISH FOUNDRYMENS' ASSOCIATION.

At the annual Convention, held in Middlesbrough, the following paper was read by MR. T. SWINDEN.—

SOME METHODS OF MEASURING HIGH TEMPERATURES.

ALTHOUGH methods of measuring high temperatures have been in use for a matter of two or three hundred years, and although such marvellous improvements have been made of late years, there still remains a large field for

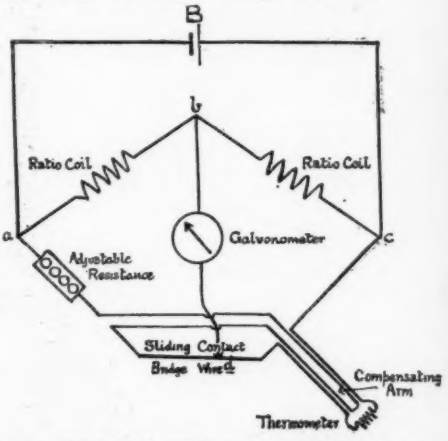

FIG. 1.—DIAGRAM SHOWING DISPOSITION OF THE VARIOUS PARTS OF ELECTRIC RESISTANCE PYROMETERS.

further improvement, and the instrument maker is quite as active in designing fresh pyrometers as the user is in applying them to his various requirements

It is interesting to note that in most of the stages of perfection the discoveries and applications have been made by practical men, *i.e.*, by men who realised the benefits to be derived from

the use of an instrument by the aid of which they could measure, and therefore regulate, the heat in their different processes.

Le Chatelier, in his book on this subject, quotes from the writings of Wedgewood in 1782 the following—"The greater part of the products obtained by the action of fire have their beauty and their value considerably depreciated by the excess or lack of very small quantities of heat; often the artist can reap no benefit from his own experiments on account of the impossibility to duplicate the degree of heat which he has obtained before his own eyes. Still less can he profit from the experiments of others, because it is even less easy to communicate the imperfect idea which each person makes for himself of these degrees of temperature." The words may be taken in a very literal sense by all users of heat, the foundryman being by no means an exception, as anyone considering correct casting and annealing will readily admit.

Wedgewood's early method was to measure the shrinkage of dehydrated fireclay, and, although very crude, it remained practically alone for a matter of 30 or 40 years. Several more or less successful attempts at better methods followed, but Siemens' was probably the first really accurate practical pyrometer, described in 1871, and based upon the change in electrical resistance of a platinum wire with change of temperature. Since this time innumerable pyrometers have been brought out, but yet, with the many really accurate and practical instruments to-day available, one must realise that each class, and in many cases each individual of a class, is suitable for one particular kind of work only, if full benefit and satisfaction is to be obtained.

The table below shows in outline the general methods at present in use for pyrometers.

As before mentioned, Sir W. Siemens designed the electrical pyrometer in 1871, and although not by any means the electrical instrument of to-day, it was undoubtedly a great step forward.

Electric Resistance Pyrometers.

To consider briefly the principle of the resistance pyrometer:—If a certain E.M.F. be applied to a length of platinum wire of definite resistance, a definite current will result, and can be measured. If now the resistance of the wire is altered, the E.M.F. remaining constant, the current will vary proportionally, according to the simple law $C=\frac{E}{R}$ This is precisely what occurs when the wire is heated; its resistance increases in proportion to the temperature, and hence the current produced decreases. The decrease in current may be measured in several ways, and in each case gives indirectly the temperature to which the platinum is subjected.

Many changes in the original design have been made, Professor Callendar being probably the most prominent in this work.

Fig. 1 shows the diagrammatic disposition of the various parts. The

Class.	Principle.	Type.	Range.
Electric resistance.	Utilizing the increase in resistance of a platinum wire with temperature.	Callendar & Griffiths, Siemens.	0-1,200° C.
Thermo electric	Depending on the electro-motive force developed by the difference in temperature of two similar thermo couples opposed to each other.	Le Chatelier, Paul, Bristol, Roberts Austen, Baird & Tatlock, etc.	0-1,400° (pt. iridium wire). 0-1,600° (pt. rd. wire).
Radiation.	Measuring the heat radiated from a hot body.	Féry's telescope.	500° to 10,000°C.
Optical.	Utilizing the optical radiations from a hot body.	Wanner, Mesuré Nouel, etc.	900° C. to 2,000°C.
Calorimetric.	Depending on the heat given to a standard metal cylinder.	Siemens' water pyrometer.	0° to 1,000°C.
Fusion.	Depend on the unequal fusibility of various metals or earthenware blocks.	Seger cones, fusible alloys, etc.	600°-1,800°C.
Pneumatic.	Flow of air through apertures at different temperatures by definite suction.	Uehling.	300° to 1,450° C.

NOTE.—To convert ° C. into °Fahr. multiply by $\frac{9}{5}$ and add 32.

battery B at the top supplies a steady current, and the theory of the wiring is this :—

$$\frac{\text{Resistance of } a\ b}{\text{Resistance of } b\ c} = \frac{\text{Resistance of } c\ d}{\text{Resistance of } a\ d}$$

The ratio coils, *a b* and *b c*, are generally made equal, whilst the thermometer forms one arm of the bridge, and the adjustable resistance and compensating arm form the other. Thus, taking the resistance of *a b* equal to that of *b c*, and supposing the sliding contact to be in such a position as to make resistance in arms *a d* and *d c* equal, then no current will flow from *b* to *d*, and the galvanometer in the centre will be at zero.

If now the thermometer coil is heated and its electrical resistance increased, the equilibrium is disturbed, and the resistance of *c d* being rendered greater than that of *a d*, a current proportional to the change passes along from *d* to *b*, and the galvanometer needle is deflected. The obvious thing to do to measure the change is to move the sliding contact along the bridge wire until the same equilibrium as before mentioned is again obtained, as shown by the return of the needle to zero. Then the amount by which the sliding contact is moved measures the change in resistance due to heating the coil, and, therefore, the temperature.

The many forms of resistance pyrometers differ mostly in the method of fitting up the bridge wire and movable contact, or their equivalent.

Fig. 2 shows Whipple's temperature indicator as used for resistance pyrometers; the battery, galvanometer, and bridge wire are all in one case. Contact is first made by switch F, and the galvanometer needle at B is brought back to zero by turning the milled head H. This moves a sliding contact round the inside of a drum, and thus over the surface of the bridge wire. A scale A, marked off in degrees of temperature, is fixed on to the outer surface of the drum, and the readings may thus be made direct. P is a laboratory pyrometer tube fitted ready for use.

FIG. 2.—WHIPPLE'S TEMPERATURE INDICATOR, AS USED FOR RESISTANCE PYROMETERS.

Fig. 3 illustrates a thermometer tube. The platinum coil, whose resistance we are to measure, is seen con-

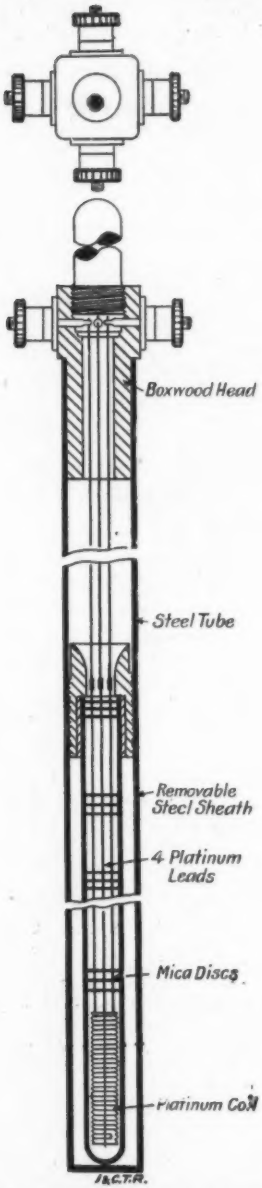

FIG. 3.—THERMOMETER TUBE, ELECTRIC RESISTANCE PYROMETER.

nected to binding screws in the head. The mica discs shown threaded along the wires are to prevent accidental contact within the tube. It will be seen that there are four wires in the tube; two lead to the coil, and the other two are known as compensating leads. They consist merely of a length of wire similar to the other leads, which passes up the tube,

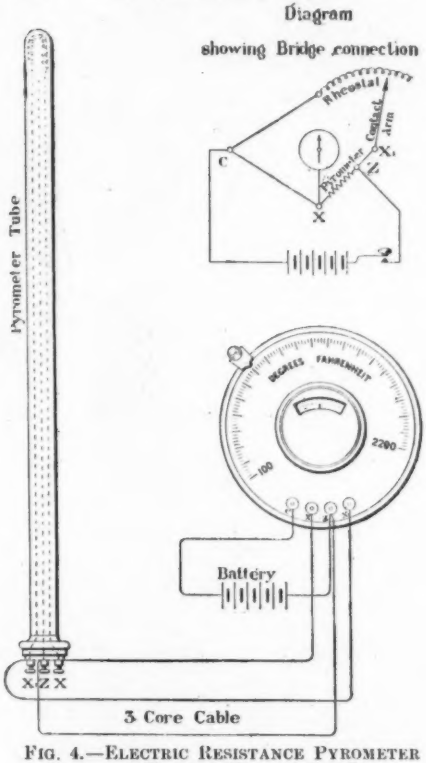

FIG. 4.—ELECTRIC RESISTANCE PYROMETER MADE BY SIEMENS BROS. & CO., LTD.

turns round at the top without touching the coil, and then returns to the head. This "compensating arm" is connected on the opposite side of the bridge, as shown earlier in Fig. 1, and the action is this. If we were to measure the change in resistance of the whole of the coil and *its* leads on heating, without any compensating, the readings would vary according as to how far the leads were heated. The compensating leads are, however, heated to precisely the same extent, and being opposed to the coil leads

exactly counteract any influence of leads, and render it immaterial as to how far the tube is pushed into the furnace or flue.

The resistance thermometer, as made by Siemens Brothers & Company, Limited, is rather different in design, as seen in Fig. 4. The diagram of the wiring is shown in the small figure. One noticeable difference is that only three wires are used in the tube instead of four as in the previous examples. The central lead serves as a return for both coil and compensating wiring. The compensating length is from Z to X^1. The bridge wire is replaced by a helical coil of wire round the edge of a circular dial set out in degrees of temperature. In the centre is a small dead-beat galvanometer. A sliding contact also fits round the edge to adjust the resistance in the variable limb of the bridge, and it is so arranged as to indicate by its position on the dial, when the galvanometer needle is back to zero, the temperature direct.

Dealing a little more fully with the pyrometer tubes, Professor Callendar showed in 1886 the inadvisability of coiling the platinum on fireclay, as Siemens had done, and advocated the use of mica instead. He was also the first to point out porcelain as an efficient protecting tube. The tube shown in Fig. 3 is a Callendar tube, made by the Cambridge Instrument Company, Limited. An immense variety of tubes are available, almost every conceivable difference in leads, protecting tubes, and head pieces, to suit all kinds of work, being made. The tube illustrated would be suitable for boiler flue and general test work, where the end only is heated to any great extent. If required for annealing furnaces, a heavier steel sheath and suitable head gear would be substituted; whilst for high temperature work no steel tube at all would be used, and no shield in the tube would be allowed.

Fig. 5 illustrates the thermometer tube fitted for use in a blast main. For laboratory use the thinner and more delicate tubes are used, since it must be borne in mind that the thicker the porcelain and steel tubes used for protecting the coil, the longer one must wait for a true reading of the temperature owing to lag. This point may be worthy of note when considering curves of recorded temperatures when the thermometer coverings are extensive.

With regard to recording instruments for use with resistance pyrometers, the ingenious apparatus of Callendar stands practically alone. Fig. 6 shows one form

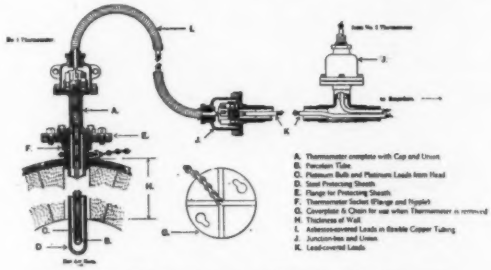
A. Thermometer complete with Cap and Union
B. Porcelain Tube
C. Platinum Bulb and Platinum Leads from Head
D. Steel Protecting Sheath
E. Flange for Protecting Sheath
F. Thermometer Socket (Flange and Nipple)
G. Coverplate & Chain for use when Thermometer is removed
H. Thickness of Wall
I. Asbestos-covered Leads in Flexible Copper Tubing
J. Junction-box and Unions
K. Lead-covered Leads

FIG. 5.—THERMOMETER TUBE, FITTED FOR USE IN A BLAST MAIN.

One or two illustrations of the use of resistance pyrometer will probably interest some present. As everyone will know, much importance is laid upon the temperature of the blast in blast furnace practice. The early methods used in this branch were very crude, depending on such things as the time for a bar of zinc or lead to melt in the blast, the colour of the outside of the main, etc. The resistance pyrometer has found very considerable use in this direction. Again, the importance of regulating the heat in an annealing furnace is obvious, and the of the instrument. The general idea is to balance the resistances automatically by means of a pair of small electro-magnets, which, controlling clockwork, allow the latter to move the sliding contact along the bridge wire. A pen fixed to the sliding contact marks on a continuous roll of paper, graduated to give the temperature, thus giving a continuous record of the latter.

application of pyrometers in this direction, as also with hardening baths, etc., is extensive.

Fig. 7 shows the variations in temperature of an annealing furnace; the different styles of firing of the two men A and B are clearly evident.

The instruments were very successfully used by Messrs. Heycock & Neville in their researches on copper-tin alloys, and by others in similar work. The fact that the resistance instruments can be applied to very low temperatures greatly enhances their value, since they can be used for refrigerator and cold stores work to advantage.

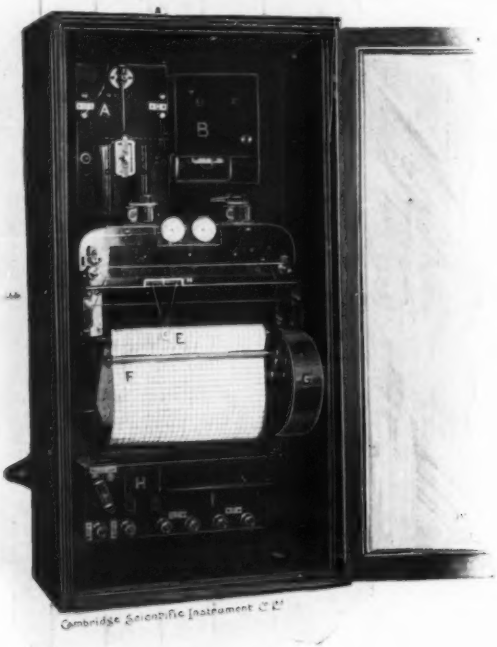

FIG. 6.—RECORDING INSTRUMENT FOR USE WITH RESISTANCE PYROMETER.

Thermo-Electric Pyrometers.

Measuring the increase in resistance of a platinum wire is not the only way in which electricity has been utilised in high temperature thermometry. It has long been known that if the junction of two dissimilar metals be heated, a difference of potential is set up, causing a current to flow through the junction. This current being proportional to the temperature furnishes a method of measuring the latter.

Becquerel, in 1826, first applied this principle, but the method had a very checkered career, owing in a great measure to the difficulty experienced in getting reliable and durable materials for thermo-couples.

Probably the greatest worker in this direction has been Professor Le Chatelier, who showed that iron, nickel, and palladium, etc., were useless, owing to their non-homogeneity after heating; platinum

and its alloys, with rhodium and iridium, were very reliable. The latter gives a more open field, *i.e.*, a greater E.M.F. for the same temperature, but it does not stand the heat quite so well. The upper limit for the continued use of the Pt-Rd wire is about 1,600 degrees C., and for Pt-Ir about 1,400 degrees; however, the life will vary very considerably according to the surroundings.

The current produced by the heating of the thermo-couple may be measured by a potentiometer method, using a standard cell and bridge wire, in which case the Callendar recorder can be used; or, the more usual way is to measure the current or its effect directly on a galvanometer. A very high resistance galvanometer is used, so that any small alteration in the *resistance* of the circuit, due to addition or reduction of lead wires, etc., will be negligible. Thus, in the installation at the Sheffield University, the galvanometer has a resistance of 220 ohms.; whilst the whole of the rest of the circuit, including leads and all wiring, is only 5 ohms., or only just over 2 per cent. of the total. Considering that it takes about 300 yards No. 12 copper wire for 1 ohm. resistance, one can easily see that a very considerable lengthening of the distance from couple to galvanometer is practically immaterial.

Now, if we take two lengths of wire, one platinum only and the other platinum with 10 per cent. rhodium, and join at either end by twisting or fusing together, we have two similar thermo-couples formed, each having the same definite E.M.F. for each temperature. Hence, if the two couples are the *same* temperature, the two E.M.F.'s. being equal and opposed to each other, will exactly neutralise each other, and no current will flow round. If, however, one junction, generally spoken of as the "hot junction," is made hotter than the other, an increased E.M.F. is set up in the one direction, and a current proportional to the *difference* in temperature of the hot and cold junctions will result. The fact that the galvanometer readings are proportional to the *difference* in temperature of the two junctions is very important. In practice, the cold junction is taken as the point where the "couple leads" join the copper wires leading to the galvanometer. Thus the whole of the rest of the circuit is used to join up the cold junction. The point of juncture should be far enough away to prevent sudden changes in temperature, and the arrangement is only strictly accurate when every junction throughout the wiring is at the same temperature. It is certainly inaccurate if corresponding terminals such, say, as the binding screws at the thermometer head, or galvanometer, are not at the same temperature. The copper leads are

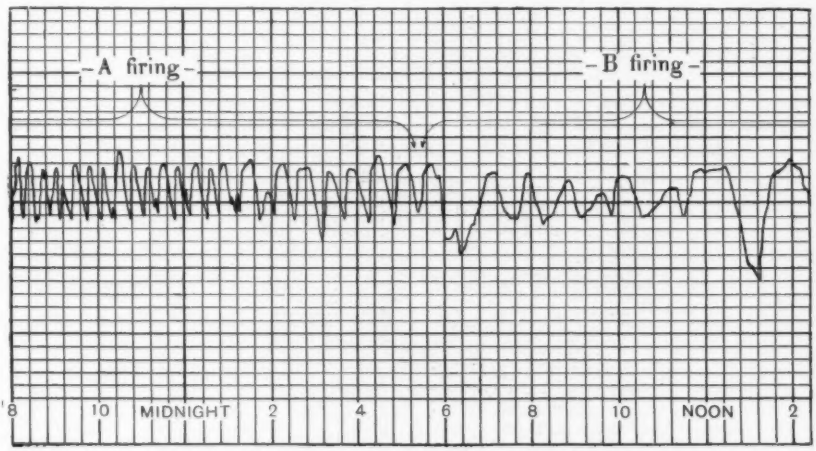

FIG. 7.—VARIATIONS IN TEMPERATURE OF AN ANNEALING FURNACE.

usually soldered on to the platinum at the cold junction, which may be kept in ice at 0 degree C. when no C.J. reading is necessary, or in water whose temperature is occasionally read. In the latter method the soldered junctions may be contained in small glass tubes immersed in water; a third tube is reserved to receive the "hot junction" when the zero of the instrument is required.

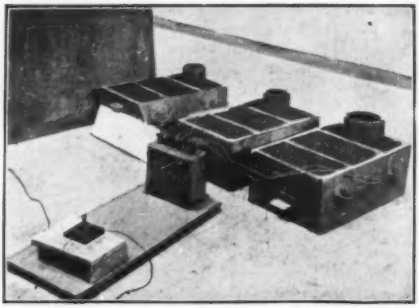

FIG. 8.—A SET OF THREE MOULDING BOXES READY FOR CASTING.

The instrument is calibrated by heating the "hot junction" to known temperatures, such as boiling sulphur, solidifying lead, and gold, and the scale reading in each case noted. Thence a curve showing the deflection of the galvanometer needle to be expected for any temperature within those limits is obtained. In such an installation as this, using one permanent galvanometer, almost any number of couples can be fitted with it. By means of a simple switch, any one of the couples can be put in circuit with the galvanometer.

With ordinary care such an installation is very durable, as the one at Sheffield bears witness. This has been in use for fourteen years, and is still in splendid condition; one or two new suspension wires for the galvanometer, and very occasional repairs to the wiring, constitute all the repairs required. Applications of thermo-couples are almost too numerous to mention, almost all the researches of recent years involving high temperature measurements having used them. We have the Recalescence Curves, of Osmond; Thermal Transformations of Metals, by Arnold; Heat Treatment and Restoration of Steel, by Stead, and others; Casting Temperature Work, by Longmuir; Cast Iron Researches, by Turner; and a great many others all using the thermo-couple.

I might quote one or two results obtained, as illustrating the necessity for pyrometry among iron and steel makers and users.

Fig. 8 shows an application of the installation just described. It represents a set of three boxes ready for casting, each mould being fitted with a bare thermo-couple. The cold junction apparatus and switch are seen in the foreground. The apparatus was designed and used by Mr. P. Longmuir in his valued researches on "Casting Temperature," and represents probably the nearest approach of the use of the thermo-couple in the foundry. One set of results taken from many will illustrate the great influence the casting temperature has on the properties of the casting. The metal in this case was red brass:—

Casting temperature in degrees Centigrade.	Elastic limit in tons per sq. inch.	Max. stress in tons per sq. inch.	Elongation per cent. on 2 inches.	Reduction of area per cent.
1,308° C.	4.28	6.85	13.25	12.65
1,073° C.	4.26	12.65	26.0	30.28
1,058° C.	4.37	5.67	5.5	6.64

A second example, from Messrs. Stead & Richards' paper on "The Restoration of Dangerously Brittle Steel." The steel

FIG. 9.—A NEW FORM OF PORTABLE INSTRUMENT.

in this case was rail steel, and the figures given represent the number of reversals of stress and strain withstood:—

Condition.	Alternating stress test.
Normal	100
Overheated	62
Reheated to 820° C.	67
Reheated to 960° C.	150 unbroken.

The wonderful action of the reheating to 900 degrees must appeal to one as indicating the necessity for accurate means of measuring these temperatures.

Thermo-electric are probably the most numerous pyrometers on the market, the differences in the various instruments being in the metals used for couples, and new indicators or recorders. The following are a few of the most important.

The Roberts-Austen Recording Pyrometer does not differ in principle from the ordinary Le Chatelier apparatus, but instead of a graduated translucent scale, a roll of photographic paper is substituted, so that the spot of light reflected by the galvanometer strikes it. The whole is enclosed

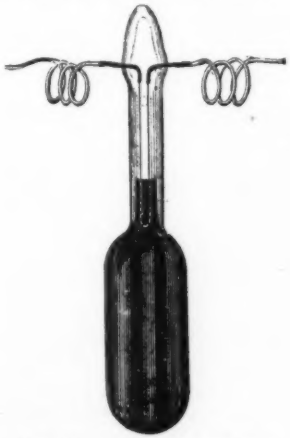

FIG. 10.—COMPENSATOR FOR THERMO-ELECTRIC PYROMETER.

in a dark box, the record being removed, developed, and marked off each morning. As many as three records can be taken simultaneously on the one instrument.

Considering portable instruments, a class which is in great variety, the instrument of R. W. Paul, of London, is very good. The ordinary thermo-couple (Pt. and Pt.-Ir.) is used in a suitable protecting tube, and a small galvanometer of unique design is employed.

An automatic lever is provided inside the instrument, so that on setting it down the galvanometer coil is free and in working order; immediately on lifting up, the coil and needle are locked fast, so as to stand any amount of rough handling. A new departure is also made with the cold junction. The ordinary instrument is calibrated before sending out, allowing for a cold junction of 16 degrees C., *i.e.*, an average temperature. However, a new form is being made in which a water-cooled junction is fitted on the end of the pyrometer tube (Fig. 9). Using the instrument with porcelain covering, a reading takes about five minutes, whilst with the bare couple half a minute is ample.

Messrs. Baird & Tatlock make several classes of instruments, notably a gimbal apparatus, which consists of a suitable galvanometer mounted so as to automatically level itself; also a combined indicating and recording instrument. This is of a semi-portable nature, and is rather more elaborate than the ordinary portable instrument.

The Cambridge Scientific Instrument Company have a new recorder out in which a connection from the galvano-

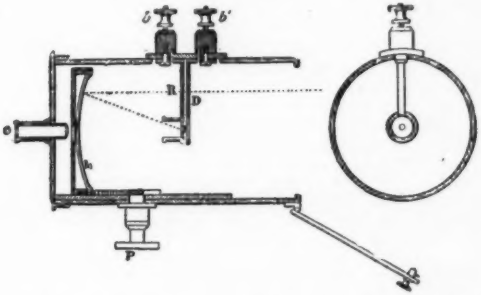

FIG. 11.—FÉRY THERMO-ELECTRIC TELESCOPE.

meter boom is depressed by clockwork at regular short intervals on to a thread moistened with ink. This in turn marks a roll of paper, furnishing a continuous record.

A comparatively recent pyrometer is that of Prof. W. H. Bristol, which embodies several new points. It is designed for temperatures up to 1,100 degrees C., and uses iron, nickel, copper, and tungsten alloys for couples, but these will obviously be more liable to deterioration than platinum. Insulation is obtained by asbestos and carborundum paint. The very sensitive high resistance galvanometer is replaced by an ordinary pivot instrument of low resistance, the argument being that the couples used

give a much greater E.M.F. than the platinum alloys, and are therefore able to operate the pivot instrument. However, changes in the circuit resistances will have to be kept within narrow limits. Instead of a cold junction reading, a "compensator" of very ingenious design is employed. It consists of a glass bulb with a short stem containing mercury (Fig. 10). Two platinum terminal wires

FIG. 12.—FÉRY THERMO-ELECTRIC TELESCOPE IN USE.

are fused into the stem near the top, and are connected within the bore of the stem by a loop of fine platinum wire. The action is simply this: If the C.J. temperature increases, the E.M.F. resulting at the galvanometer will decrease, since this is proportional to the difference in temperature of the hot and cold junctions; but here, if the temperature increases the mercury will expand, rise up the tube, and cut off a certain part of the platinum wire acting as a resistance, and thus proportionally increase the current. The compensator must, of course, be standardised, and is also only applicable for a low resistance galvanometer.

Now in all the pyrometers dealt with so far, electrical principles have been used. I now propose to deal with those based upon

Radiation and Optical Methods.

The gauging of the temperature of a body by the colour of the glow is undoubtedly the oldest method used, but the uncertainty and inadaptability of the method is, of course, obvious. However, when the optical effects of a glowing body are scientifically measured, we have an ideal method, since small increases in temperature greatly increase the luminous intensity. Thus if the red rays from platinum at 1,000 degrees C. be represented by 1; at 1,200 degrees they would be 10; at 1,500 degrees, 130; at 1,800 degrees, 804; and at 2,000 degrees they would be over 2 100.

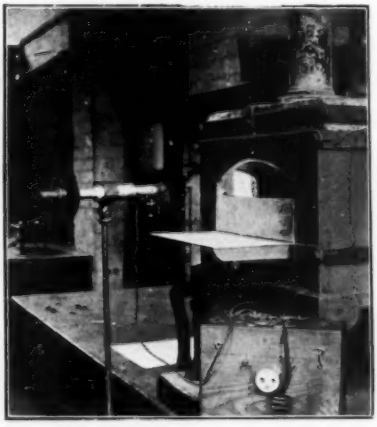

FIG. 13.—THE WANNER OPTICAL INSTRUMENT.

The great drawback with optical pyrometers is the fact that different bodies emit vastly different amounts of light when at the same temperature.

Kirchoff was the first to conceive what he called a "black body," which he described as one absorbing all radiations falling upon it, and neither reflecting nor transmitting any. From such a body the radiation is a question of temperature only. However, no body is known which acts perfectly as a black body, but carbon and iron and metals with black oxides act very nearly so. Also all bodies placed

inside a heated chamber and kept there until the whole is uniformly heated, will act as black bodies. Thus in metallurgical practice the interior of most furnaces, and also molten iron and steel, act very approximately as black bodies.

As regards heat radiations, we know that the quantity of heat depends upon the latter's temperature, surface, distance away, and emissive power. Many forms of radiation pyrometers have been described, but the only one of practical importance is Féry's Thermo-Electric Telescope.

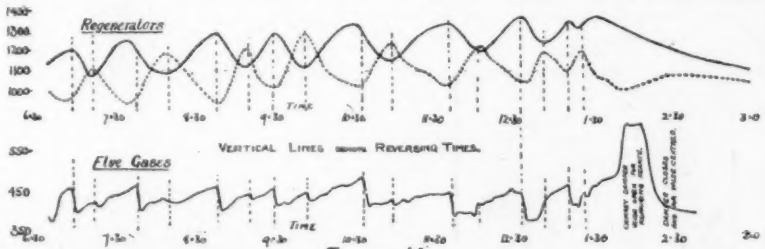

FIGURE 14

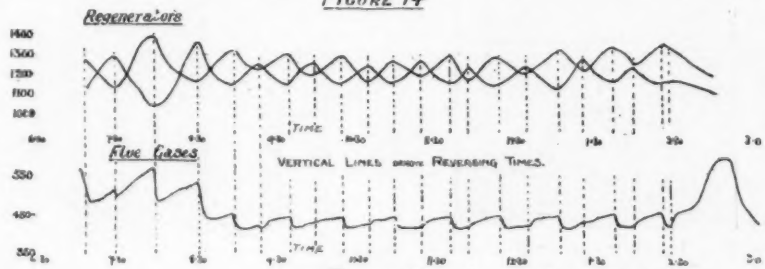

FIGURE 15

VARIATIONS IN TEMPERATURE OF THE TWO AIR REGENERATORS OF THE SIEMENS' FURNACE.

The arrangement is shown in Fig. 11. M is a movable concave mirror in connection with screw P. At the focus of M is placed a very minute thermo-couple of copper constantan; the leads from this go by the way of the terminals b and b^1, to a very sensitive galvanometer. When making an observation, one focusses on to the body by means of screw P, viewing through eye-piece O, two small mirrors near the couple indicating when this focus is obtained. Then the temperature is read off direct on the galvanometer.

The size of the body under observation, or the distance away from it, is without influence, unless the image seen does not cover the thermo-couple, in which case a low result would be obtained. In general, one requires about 1 in. observation surface per yard distance away. It was found by experiment that a stream of molten steel showed the same temperature when viewed at distances of 3 and 60 ft. away.

The lower limit of the instrument is about 600 degrees C., and there is practically no upper limit. The instrument is standardised against a thermo-couple, or against a specially constructed Féry instrument, before sending out. One good feature of the instrument is that the couple is never heated above 80 degrees C., and therefore does not suffer from prolonged use, as do the ordinary thermo-couples.

Fig. 12 illustrates the Féry instrument in use.

Considering optical instruments, probably the most successful is that of Prof. Wanner (Fig. 13). It is based upon the photometric comparison of the intensity of red rays in the light emitted from a standard lamp with those from the incandescent body whose temperature is sought. In using the instrument, one views on to the body in question, and sees a semi-circle of red light; the

other half of the circle is illuminated by connecting up with the battery, lighting the standard lamp. The intensity of the latter half is varied by rotating an eyepiece until the whole circle is one homogeneous tint. The position of the eyepiece, as shown by the small arm attached, is read off on the graduated scale round the rim, and gives the temperature on reference to tables supplied.

As the optical principles are rather beyond such a paper as this, I do not propose to enter into them now. Moreover, to the practical man they are probably of little interest, since they, unlike the electrical principles, are altogether beyond his control.

FIG. 16.—THE MESURÉ AND NOUEL OPTICAL PYROMETER.

The instrument is adjusted by the makers, and they supply what is called a "normal point." When standardised to test the lamp, one compares the electric lamp against a small wick lamp burning amyl acetate in a specially constructed box. The rotating arm is set at the "normal point," and if the two half-circles of light are not identical, the position of the electric lamp, relative to the body of the instrument, is altered by a small screw until this is the case. An alternative method is to alter the current by means of a rheostat. This standardising requires, say, 10 minutes, and should be repeated every day.

As illustrating the use of the Wanner instrument, the following figures obtained by the author at the Sheffield University may be found interesting. The first shows some readings taken of the cupola metal from a 40 in. cupola:—

Time.	Approximate weight tapped.	Tapping temperature.	Casting temperature.
	Cwts.	Deg. C.	Deg. C.
4.10 p.m.	6	1,280	1,240
4.33 ,,	11	1,350	
4.40 ,,	4	1,316	1,274
4.55 ,,	5	1,325	1,255
5.0 ,,	5	1,355	1,250

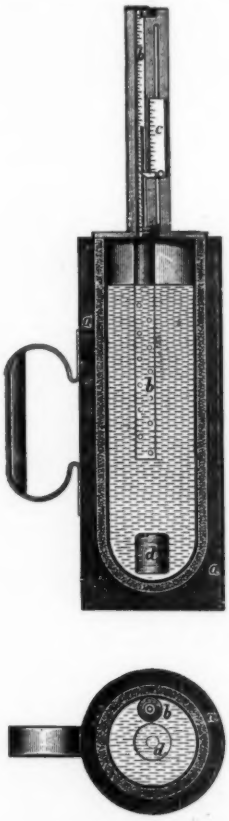

FIG. 17.—THE SIEMENS' WATER PYROMETER.

The next table shows readings taken in connection with Mr. Adamson for his

paper on "Chill in Cast Iron" ("Journal Iron and Steel Institute," 1905, No. 2):—

Combined carbon.	Graphite.	Temperature.	Chill.
Per cent.	Per cent.	Deg.	In.
.74	2.58	1,298 1,215	$\frac{3}{4}$ $\frac{5}{8}$
.90	2.53	1,282 1,194	$1\frac{1}{4}$ 1
1.65	1.68	1,274 1,229	$1\frac{1}{4}$ $1\frac{1}{4}$

The well-known fact that the higher the temperature and the deeper the chill is clearly demonstrated.

The following are a few readings taken at the "Pig Wash" for the 2-ton Siemens' furnace :—

Furnace just before tapping, 1,643 degrees C.; tap, 1,355 degrees C.; shanked from ladle in lots to suit castings at temperatures of 1,316, 1,298, 1,290, 1,258, 1,236, 1,222 degrees C. Time from first to last cast was about half an hour.

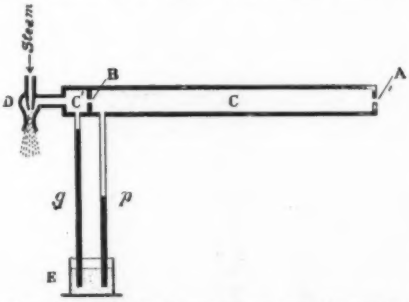

FIG. 18.—THE PRINCIPLE OF THE UEHLING PNEUMATIC PYROMETER.

The next example shows temperature observations on the furnace and metal during a Siemens' heat for mild steel :—

	Degrees C.
Furnace at 9.40 a.m....	1,560
Charged at 9.45 a.m	
Charge melted, 11.35 a.m.	
Metal (or slag) at 12.10 p.m.	1,600
" " 4.0 "	1,628
" " 4.15 "	1,632
" " 4.30 "	1,620
" " 4.37 "	1,623
" " 4.45 "	1,649
" " 5.0 "	1,655
" " 5.15 "	1,680
" " 5.30 "	1,665
Tapping at 5.35 p.m.	1,466
Casting first ingot	1,443
" last "	1,413
Furnace during "drying up"	1,585

The average of many tapping temperatures of the Siemens' is about 1,475 degrees C. with steel about 0.30 per cent. carbon. A crucible steel of similar temper would under ordinary conditions be cast about 1,450 degrees.

Figs. 14 and 15 illustrate the variations in temperature of the two air regenerators of the Siemens' furnace, together with the flue, gas readings taken at the same time with the Paul instrument. The rise and fall on reversing, together with the effect on the flue gases, is interesting. The two sets illustrate the working, by two different men, of the same furnace.

The Wanner is by no means the only optical pyrometer; a great variety of these instruments have been brought out, but with few exceptions they have been more theoretical than practical. The only other one I propose to mention is that of Mesuré and Nouel (Fig. 16).

On viewing a heated body through this instrument, one sees an illuminated circle, and by turning the eye piece, to which is attached a graduated scale, the colour seen changes through the spectrum.

To obtain the temperature, the eyepiece is turned until one reaches a neutral tint changing from green on one side to yellow on the other. Thence by reading off the scale, and referring to tables supplied, the temperature is obtained. The apparatus is very handy, but, unfortunately the neutral tint is by no means well defined to the ordinary person, and it undoubtedly differs with high and low temperatures.

Leaving optical pyrometers, I might mention briefly the Siemens' Water Pyrometer, with which no doubt you are all familiar (Fig. 17). The idea of the working is to heat a small cylinder of either copper, iron, or nickel, at the spot whose temperature is required, and then measure the heat in it by the rise in temperature it causes when dropped into a definite amount of water. A pint of water is used, and is contained in a double copper vessel, suitably protected from draughts, etc. A thermometer fixed on to a brass plate dips into the water, and attached to this plate is a sliding scale with pointer. To take a reading, the pointer is fixed at the mercury level in the thermometer; then the heated cylinder is quickly dropped in, and the water stirred until the mercury stops rising. Then the thermometer reading, and also the scale reading directly opposite, are taken, and the sum of these two gives the

temperature in degrees. The theory is very simple, the scale reading being calibrated to suit the fixed quantities concerned, *i.e.*, the weight of water and cylinder and the specific heat of the latter. Then the only variable after setting the pointer is the final temperature which is to be measured. For temperatures up to about 1,000 degrees C., iron and copper cylinders may be used, and, as they lose weight by scaling, a table of factors for correction is supplied.

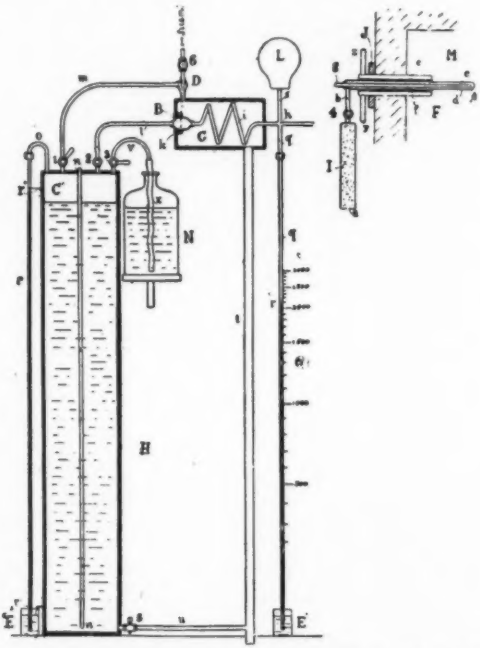

FIG. 19.—UEHLING PNEUMATIC PYROMETER. DIAGRAM SHOWING DISPOSITION OF THE PARTS IN PRACTICE.

The weights of the different cylinders are such as to make them interchangeable with the one instrument, and scale.

Turning next to the Pneumatic Pyrometer of Uehling with the Steinbart Recorder, the instrument used so largerly for blast mains, etc.

Fig. 18 illustrates the principle of the instrument. It is based on the laws governing the flow of air through small apertures. If two small apertures A and B form respectively the inlet and outlet openings of a chamber C, and if a uniform suction be created in chamber C^1 by the aspirator D, the action will be as follows: Air will be drawn through the aperture B into chamber C^1, creating a suction in C, which in turn causes air to enter A, so that the velocity with which air enters at A depends on the suction in C; and the velocity with which it flows out through B will depend on the *excess suction* in C^1 over that in C. Now, since the total suction furnished by aspirator D remains constant, and therefore if by any means the suction in C increases, the *effective* suction in C^1 will necessarily decrease. Thence the inward flow at A would increase, and the outward flow at B decrease, until equilibrium is reached, and the two rates of flow are identical.

Again, since air is expanded by heat, the higher the temperature the greater will be the volume, and consequently, for a definite volume, the smaller will be the quantity of air. Hence, the higher the temperature the smaller is the amount of air drawn in through A.

Now, if the air is heated on entering at A, and cooled again to a definite temperature, less air (by weight) will enter A than is drawn out through B. Then the balance is again obtained as before until the same quantity of air enters A as flows out at B. Thus every change in temperature of aperture A will cause a corresponding change in the suction in C, since the *quantity* of air drawn through is constant, and since the volume and therefore the pressure or suction depend on the temperature.

The suctions in C and C^1 are registered by manometer tubes, *q* representing the constant suction in C^1, since aperture B is kept at constant temperature, and *p* indicating the variable suction in C, which suction is a true measure of the temperature of aperture A.

Fig. 19 shows the diagrammatic disposition of the parts in practice. Aperture A made in the end of platinum tube is in the furnace, and aperture B is suitably contained in an iron box into which the steam from the aspirator exhausts. The tube *e*, *f*, *g*, *h*, *i* from A to B, together with branches *q* (to manometer tube) and *s* (to recording gauge) constitutes the chamber C. The air is filtered through cotton wool before use, so as to prevent any damage to the aperture. The only suction pressure it is possible to create in C^1 when bubbling the water in the regulator, gently, will be measured by the height of the water from n^1 to the surface, or as shown in tube *p* in the diagram from *r* to r^1. It will be seen that the tube *s* taken off at the same point as the manometer tube leads to the recording gauge (Fig. 20).

This consists of a vertical glass cylinder containing mercury, in which floats a glass bell. Attached to this is an adjusted balance weight, and also a small horseshoe magnet carrying a pen. A small bar placed near ensures the pen always touching against the continuous roll of paper moved slowly past by clockwork. Horizontal lines giving temperature graduation, are marked by a special roller over which the paper passes previously. With regard to the action of the float, atmospheric air is admitted into the inside of the floating bell, whilst the outer chamber is connected by a pipe to the suction, as already described. Hence as the suction increases, the float is lifted further and further out of the mercury in which it floats, and the hanging rod with the pen attached traces out a line on the paper accordingly.

Fig. 21 shows the instrument complete with fire tube and recorder. The apparatus is not so delicate as one would at first imagine. One instance of this durability, communicated to the author by Mr. J. H. Harrison, of Middlesbrough, was seen when dynamiting the old "bear" out of the bottom of a blast furnace close by the Uehling house. The windows and slates were shattered, but the instrument worked continuously, and actually recorded, by the concussion, each explosion. The pyrometer stood this for about 10 days with several shots a day, but, finally, one day the screwed case covering the balance weight was off when the explosion took place, and the inner glass float was broken. Outside shocks such as are due to hammering, etc., cause a slight vibration to and from the paper, but cannot alter the height of the float (and pen) determining the temperature.

The one instrument may be fitted with 2, 4, 6, or even 8 separate fire tubes, indicators, and recorders. This is important, as the cost is thereby considerably lessened.

There are a few of the simpler and cheaper methods of high temperature measurement yet to be mentioned. Firstly, the Seger cones, depending in principle upon the softening point of a series of fusible cones made to indicate from 600 to 1,800 degrees C. at intervals of 25 degrees. They consist of silica and alumina softened with oxides of iron, lead, and bismuth, etc. Three or four cones are used each time so as to cover the range wherein the temperature is expected. The first cone whose apex assumes a downward direction due to softening is taken, and the number stamped on it gives the temperature on reference to tables. In the admirable paper by Dr. Boudouard on the "Fusibility of Slags" ("J.I.S.I.," No. 1, 1905), these cones were used throughout for temperature measurement.

Fusible alloys and pills are also used, being used much in the same way as the above. The thermophone of Wiborgh consisted of a refractory shell containing a small quantity of coloured fire or explosive, and the time from this entering the furnace to the time of explosion, taken by means of a stop watch, was proportional to the temperature.

Now, as the chief aim of such a paper as this is to enable anyone interested to choose for himself, at least to some extent, the pyrometer most suitable for his requirements, I would like before concluding to mention as quickly as possible the uses and applications to which the

instruments best lend themselves. The points considered are as follows:—Accuracy, cost, range of reading and field of application, time necessary and skill required for taking a reading, portability and life under works conditions, the degree to which the personal factor is felt, length of time before restandardising is necessary, and the facility afforded for such restandardising.

Electrical Resistance Pyrometers.

Their accuracy is unquestioned. They are rather expensive. The tubes cost from £3 to £17 each, depending on the build; the Whipple indicator, about £20; Callendar recorders from £40 to £70. An outfit for recording the temperature of an annealing stove, or blast main, would cost about £55. Of course, all the prices given are more or less approximate, and are quoted for sake of comparison only. The range of working is large, but temperatures above 1,200 degrees C. are not taken with certainty. One drawback is the lag, which must inevitably occur when using the thermometer with the usual porcelain, and possibly steel, protecting tube. Ten minutes is an average time to wait for a reading, say at 900 degrees C. Whilst requiring some little training before becoming competent, the actual skill required is not great, and no personal factor comes in. The recorder is certainly most ingenious and useful where suitable, but is not advisable where great vibrations or magnetic shocks are in vogue; of course, they can be placed at great distances from the actual thermometer. The indicator is a most reliable and portable instrument, and although the batteries, etc., will in time need repair, this should not trouble the ordinary user. Since repeated heatings to near 1,000 degrees C. will in time cause deterioration of the platinum, occasional restandardising will be necessary, and here the resistance pyrometer is rather at a disadvantage in that its standardisation is not within the reach of the ordinary user.

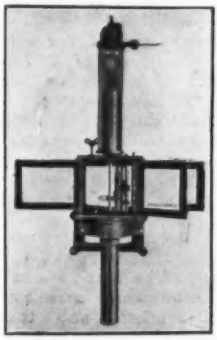

FIG. 20.—UEHLING PNEUMATIC PYROMETER, RECORDING GAUGE.

Thermo-Electric Pyrometer.

Although not possessing, perhaps, the same precision as the resistance pyrometer, the thermo-couple is undoubtedly quite accurate enough for all practical purposes. An accuracy within 5 degrees C. can be obtained consistently with a good instrument. The cost varies somewhat with the different makes. A complete set with tube and portable instrument will run anything from £7 10s. to £15; the semi-portable apparatus of rather more delicate make costs from £20 to £30, whilst a recording instrument alone will be about £40. Since the couple is so very small, the application for all kinds of work is very wide. The upper limit surpasses that of the resistance pyrometer, readings up to 1,600 degrees C. being safely taken with Pt.-Rd. couples. With bare couples, the true reading of temperature is indicated within one minute of putting the couple in, and their protection is not so exacting as with the former instruments. Here, again, no especial skill is necessary for their use, but one must have some idea as to the principles and limitations of the instrument for successful working. One is rather at a loss for a good recorder for the thermo-couple. The photographic methods are not very handy, since apart from trouble in manipulation, they are always behindhand. The thermo-couple has been shown by experience to be very constant and reliable with ordinary usage, and the ready means by which it can be restandardised is greatly in its favour.

Optical and Radiation Pyrometers.

These possess both unique advantages and unique disadvantages. In general, they are indispensable for temperatures above 1,600 degrees C., and for moving bodies; but they are only accurate when used on "black" bodies.

The Féry telescope and outfit cost about £26 for indicating, and £40 for recording. The accuracy when working on molten iron and steel or high temperature furnaces is unquestioned. Tested against a thermo-couple at the Washington Standards Bureau, from 950 degrees to

1,450 degrees, the average difference in eight readings was only 4½ degrees C. When once within focus, the time required for a reading is under two minutes, and very little skill is required in focussing. As before mentioned, the range is practically infinite above 500 degrees C. Distance has little or no effect in clear atmospheres; and surrounding light does not, within limits, cause trouble. The Féry is unique among this class in possessing facilities for continuous recording, and also of direct reading of temperature. It is fairly easily manipulated, though not quite so good in this respect as the Mesuré-Nouel or Wanner. There is nothing in the instrument to deteriorate, and the personal equation is practically without effect.

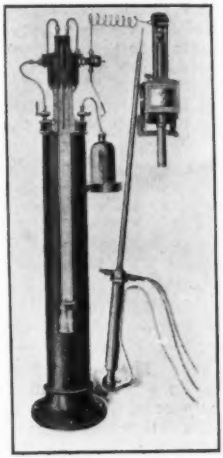

FIG. 21.—UEHLING PNEUMATIC PYROMETER COMPLETE.

The Wanner instrument is, I believe, quite as accurate as the Féry with care, but the personal factor is undoubtedly more in evidence, and one needs some practice before full benefits can be obtained. The price is about £21 for ordinary working, and the range of working from 900 degrees to 2,000 degrees C. It is easily portable, and a reading only occupies about half a minute. The distance has no effect on the tint, but one must remember that unless within a limited distance, especially in such cases as casting metal, etc., the image seen is very small, and hard for comparison. The clearness, or otherwise, of the atmosphere is also a point worth considering. Steaming moulds and fuming crucibles are apt to be awkward. With regard to deterioration, we have the lamp and battery to consider. The battery needs re-charging about once a fortnight, and the lamp should last 1,000 hours continuous lighting. The Wanner is alone among opticals as regards the easy standardising, but the repeated standardising necessary is rather a disadvantage.

The Mesuré-Nouel pyrometer, although theoretically excellent, and undoubtedly the handiest instrument made, is unfortunately lacking in sensitiveness, and is not to be advised for the ordinary run of temperature measurements. It may possibly be found an advantage where it was purposed to keep a constant temperature, but even in such a case would not be much in advance of eye judgment.

The Water Pyrometer.

This is accurate within 10 or 15 degrees C. with care, up to about 1,000 degrees C., and has probably a wider use than many imagine. Its low cost (about £4 complete) and durability, together with the fact that the errors are not cumulative, are all in its favour. Of course, it has not the accuracy of the resistance pyrometer, or the adaptability of the thermo-couple or optical instrument, but for intermittent readings, where applicable, it is very useful and reliable. Very little apprenticeship is necessary, and the chance of breakage very remote. As with the optical instruments, one instrument will serve for any number of furnaces with very little inconvenience.

The Uehling Pyrometer.

This needs no commendation here in point of accuracy and sensitiveness. The one serious drawback is the price; a single instrument reaches close on £180, one for two furnaces being about £215. The general range is from 300 degrees to 1,450 degrees C., and for taking continuous records of hot gases is probably unsurpassed. It is unaffected by ordinary vibrations and magnetic influences, and when once set in, the instrument requires little or no attention. Of course, portability is out of the question, and there is a chance of occasional trouble with the fire tubes. The recorder is a great advantage, requiring practically no attention; the record for the last seven hours is always in view, and can be detached without interfering with the progress of the recording.

Finally, the Seger cones, and the like,

whilst fairly accurate and workable under somewhat restricted conditions, are rather primitive, and possess many serious drawbacks. Moreover, the cones are, say, 1½d. each, which means each reading costs 4½d. or 6d., which, after all, is not very cheap.

In concluding this somewhat hurried review, I would just like to repeat one of the statements made earlier in the paper to the effect that no one instrument can be expected to serve all classes of work, even in the foundry, and that one must specialise on the instrument most suitable to the particular work one has in view.

My very best thanks are due to Mr. Percy Longmuir for his kindness and help afforded me in preparing the paper; also to Mr. J. H. Harrison, Mr. R. W. Paul, the Cambridge Scientific Instrument Company, Limited, Messrs. Baird & Tatlock, and others for the loan of slides and blocks and for information. Mr. E. L. Dickenson kindly made several of the slides at my request, and is to be gratefully thanked. Finally, I thank the Association for the facilities given for the reading of the paper, and for their reception of it.

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PIPE FOUNDING.—V.

Specifications and Inspection.

By W. E. Cowens.

In all large pipe contracts specifications are drawn up by the buyers stipulating their requirements. As many of the clauses require the careful consideration of the manufacturer, this article will examine closely those that usually require attention:—

In a specification before me *Clause* 1 is an interpretation clause defining whom "contractor," "engineer," and "company" shall mean.

Clause 2 relates to sub-letting, and specifies that "no sub-letting will be allowed without the consent in writing of the engineer, and that such sub-letting, if allowed, shall not relieve the contractor from his obligations under the contract. It also specifies that no reward or gratuity of any kind shall be given to any person employed by or for the company." This clause is reasonable, but the contractor must be careful, should he sub-let, to place the sub-contractor under the same conditions as he himself is bound by.

Clause 3 defines the kind of pipe required, and specifies that they "must be in accordance with the drawings supplied by the engineer, and the consent of the engineer must be obtained in writing for any deviation therefrom."

Clause 4 specifies that the pipes shall be cast socket down, "with a head of not less than 12 in. at the spigot end, which shall afterwards be cut off in the lathe. The straight pipes shall be cast in dry sand moulds, and the specials in dry sand or loam, as shall in each case be directed by the engineer or his inspector. The contractor shall supply turned iron patterns, and shall use boxes, core spindles, etc., for the making thereof; the flanges, sole plates, spindles, and cores of which shall be kept accurately turned, faced and bored, and truly fitted and joined." A good deal of this clause is superfluous; it would be better to give the manufacturer a free hand both in regard to the manufacture and patterns. It should not be competent for the engineer or his inspector to define how the pipes shall be made. It is the engineer's business to see that he obtains a good pipe; but it is the manufacturer's business to make it.

Clause 5.—"The metal must be free from slag or inferior material, and must be remelted in a cupola or air furnace. It must be strong, tough, close-grained, as free as reasonably may be from phosphorus, sulphur, and silicon, and as hard as can reasonably be drilled and tapped and shall not present a vitreous appearance on being broken. The transverse test shall be 28 cwts. on a 2 in. by 1 in. bar, 3 ft. between supports, and the tensile test not less than 8 tons per square inch." It would be better for the engineer to specify the tests only, as an inspector may find all kinds of complaint with the metal under this clause. With regard to remelting, pipes are being cast direct from the blast furnace, and there is no reason why satisfactory results should not be obtained. It should be allowed, provided the tests are obtained, and that the subsequent water tests are satisfactory.

Clause 6.—"The pipes shall be perfect and free from all defects, they shall be as nearly as possible concentric; any pipe being ⅛ in. thicker in any one part than in any other part of the barrel shall be rejected. The sockets must not be enlarged or decreased by more than ⅛ in. from the sizes indicated on the plans, any extra lead required for jointing from this cause to be paid for by the contractor. Pipes must not be taken too soon from the moulds." The margin of variation in the barrel is too small, and should not be less

than $\frac{3}{16}$ for all pipes above 30 in. diameter. The sockets will also vary, but with care the margin will be found sufficient.

Clause 7 specifies the length and weight of the pipe, that "consecutive numbers, maker's name and date, and certain letters, generally the company's initials, are to be cast on, and that after blacking the weight shall be painted on in white inside the pipe. The pipes will be paid for up to the maximum weight allowed in the schedule, but all pipes below the minimum weight in the said schedule will be rejected." The marking and numbering is reasonable and necessary, but the variation allowed in the weight needs careful attention, as it is frequently too small, and entails a great hardship on the manufacturer. It would be much better that the engineer should specify the variation in thickness that he will allow, and that the manufacturer should be paid for the actual weight delivered. The deviation in weight allowed will, in many cases, be found not more than would be represented by $\frac{1}{64}$ in. in thickness, and if the pipe were to be turned and bored the engineer could scarcely ask for greater accuracy. It seems unreasonable, therefore, to require it in a casting, and speaks highly for the manufacturers who have for so long accepted such a condition.

Clause 8.—"The pipes are to be tested after being properly cleaned and fettled, by being rolled on a suitable gantry and callipered for thickness, and then tested by water or coal tar oil to a pressure corresponding to the vertical head given in the schedule. They shall be absolutely dry under test, and shall not show any sign of porosity. Any pipes rejected for any cause must have the number and name immediately chipped off." This clause is reasonable, but the contractor should stipulate that pipes showing slight porous places should be allowed to be laid by for a few days and retested before final rejection. It must also be remembered that the oil test is much more severe than water test, as a porous pipe will not take up on being laid by. If the porosity is slight, it should be allowed to be blacked, and then if absolutely dry should be accepted.

Clause 9.—"The pipes before becoming rusty are to be dipped in Dr. Angus Smith's solution; for this purpose they are to be reheated in a stove properly constructed to the satisfaction of the engineer to a temperature of 300 degrees F., and are then to be dipped into a nearly boiling preparation of the solution." The construction of the stove should be left entirely with the manufacturers, and also the temperature. It should be sufficient that the coating be of a good glossy black, hard and dry, and that it will not chip or flake off on being hammered.

Clause 10.—"The pipes are to be inspected at the maker's works, etc., etc., The company also reserve the right to retest the pipes after delivery to site, and to reject any pipes found unsound or defective. The contractor shall replace any pipes which may prove unsound by reason of original defects within three months after the main has been filled with water, and shall also reimburse the company for all costs, charges, and expenses to which they may be put or become liable through any such failure." No manufacturer should be responsible for inspection and testing which are not conducted in his own works. Consequental damages named in the last clause should not be entertained. The fairest way to cover both these clauses would be by insuring against them, and to allow in the contract a prime cost sum to cover such insurance. A pipe bursting in a large main may cause thousands of pounds damage, and it is unreasonable to place such a risk upon a contractor.

Clause 11 relates to any dispute arising between the contractor and the purchaser, and specifies that the decision of the engineer shall be final and binding in all such cases. This is obviously unfair, and it speaks volumes for the integrity of engineers that manufacturers should so long have accepted it. It is, to say the least, inadvisable to make the engineer the arbitrator in regard to his own specification. The usual arbitration clauses, as recommended by the Institution of Civil Engineers, should be adopted, as it is absolutely fair to both parties.

A common socket pipe is such a simple casting, and the plant used in its manufacture so well adapted for its purpose, that it might be supposed that anyone will do for a pipe inspector. This is a great mistake, and is a matter which requires the careful consideration of engineers who have to make the appointment.

A pipe inspector should have some knowledge of moulding, and of the materials used, and a thorough knowledge of pipe plant and accessories, and of the best methods of making and testing pipes; he should be able to calibrate, keep the necessary books accurately, and to state clearly against any rejected pipe,

the cause of its rejection. A good inspector should be well paid, and be beyond bribery in any form.

Some of the best inspectors manufacturers receive at their works are those sent out by the Admiralty. They are all trained in the dockyards, and if necessary could make the article they are required to inspect, and are of the greatest assistance to the manufacturers. These are the type of men manufacturers welcome, and they undoubtedly best serve the interests of their employers.

In dealing with the specification only those clauses which are considered important have been taken; it is not intended to be a complete specification, nor are the clauses necessarily in their usual sequence.

THE FARWELL MOULDING MACHINE.

It is now seven years since the original Farwell machines were introduced, and there are now between 500 and 600 of them in constant use in Great Britain. The Farwell machines are of two types, namely, simple presses with adjustable horizontal lever enabling the labourer to exert a pressure of two tons on the mould without excessive muscular exertion, and Universal machines which combine the press with devices for removing the pattern from the finished mould, either by mechanically lifting the box from the pattern or by drawing the pattern through a stripping plate, as may be more suitable for the pattern being moulded. A simple

FIG. 1.—FARWELL 30 IN. STATIONARY UNIVERSAL MOULDING MACHINE.

and effective type of pneumatic vibrator, which is also illustrated, is frequently used with the Farwell machine to accelerate and secure the separation of pattern from sand without breaking away the sand.

For the Farwell moulding machine the following points are claimed:—1. The rocker shaft bearings are turned and oscillate in long bearings protected from the sand. 2. The table consists of cross bars on which the board cleats rest. There is no unnecessary space whereon sand can accumulate. 3. The table and presser top are planed true. 4. Steel is used for draw bars, pitmans and pins that are subjected to strain when pressing the mould. 5. The side rods are connected to each other at the bottom by a shaft and at the top by the presser top, so that the presser top will not get twisted or winding should the adjusting nuts loosen. 6. All working parts are above the sand, and are not subjected to the wear other machines receive. 7. It is more quickly operated than any other press. One motion brings the top in position, and presses the mould. 8. The lever is in a horizontal position when pressing the mould, where it receives the greatest power with the least exertion on the part of the operator. Presses with vertical levers strain the arm and chest muscles of the operator. 9. The lever is adjustable to conform to the size of the mould and the weight of the operator. A large mould is pressed as easily as a small one.

It is by far the most powerful press made. Moulds as large as 18 in. by 22 in. or 16 in. by 24 in. can be pressed with ease. The ratio of leverage is 30 to 1 with full length of lever. When the lever is properly set, every mould receives the required pressure without judgment or care on the part of the operator, who simply leans his weight upon the lever.

In the Universal machine the lift lever is convenient and easily operated. The lift table is guided in its vertical movement by a single long slide, which is protected from the sand, and is adjustable to take up wear. The lift table does not support the patterns when the mould is being pressed, but lifts the mould and stripping plate off the patterns after it is pressed. Patterns cannot spring under pressure, as they rest firmly on the stationary press table. They cannot be clogged or in any way injured by sand, or be thrown out of adjustment carelessly or maliciously.

When used as a flask lifter (a stripping plate not being used), the patterns are secured to one side of a board or plate. This pattern plate has tubes or holes near the edge, front and back, through which

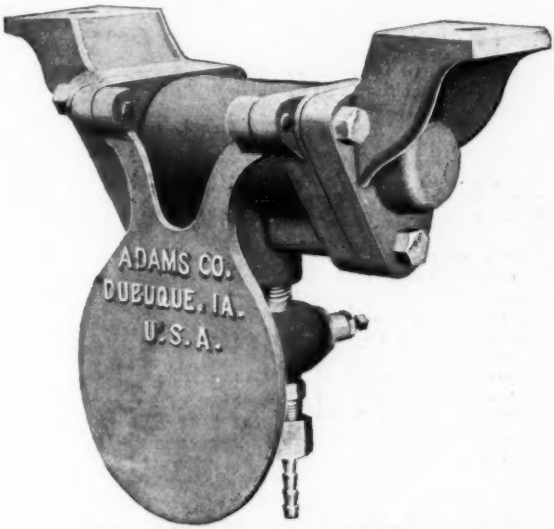

FIG. 2.—FARWELL PNEUMATIC VIBRATOR.

the loose studs drop and rest on the lift table. When the lever is raised the studs engage with the edge of the flask and lift the mould off the pattern plate. When used with a stripping plate, the pattern plate or frame to which the patterns are secured rests firmly upon the stationary press table. The stripping plate rests firmly upon the pattern plate. Three or four studs are secured to the stripping plate, which extend down and rest upon the lift table. These studs engage with guides on the pattern plate and guide the stripping plate in its vertical movement.

Messrs. J. W. Jackman & Company, Limited, always carry a large stock of Farwell machines at their Manchester warehouse, 347, Chester Road, Cornbrook, Manchester, where they will be glad to show the various types of machines to any foundrymen interested.

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PATTERNS FOR SYPHON BENDS IN STUCCO.

Plaster of Paris, or stucco as it is more commonly called in the foundry, has of late years taken a very prominent place among the materials used in the construction of patterns. In no branch of the trade of pattern-making has development been so marked as in the working of this material.

Its value for certain classes of work cannot be over-estimated, and by its free use many patterns can be "run up" at

Fig. 1.

a mere nominal cost, compared with the cost of the same pattern when made in wood.

Plaster of Paris is a soft, white powder, prepared from gypsum (hydrated sulphate of lime) by reducing it to the anhydrous state by calcination at a temperature not exceeding 127 degrees C.

Gypsum is a term applied to amorphous sulphate of lime; it has evidently been formed by the decomposition of the iron pyrites, giving rise to sulphuric acid, which, uniting with the chalk, formed sulphate of lime.

If the temperature of 127 degrees C. be exceeded, the gypsum fuses, and the powder obtained from it does not, when made into a paste with water, readily "set" or harden, the physical property on which the great utility of Plaster of Paris depends. It is not our intention, nor is it possible within the limits of an

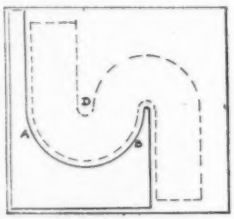

FIG. 5

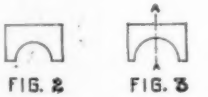

FIG. 2

FIG. 3

FIG. 4

article such as this, to go fully into the subject of stucco work, but we wish only to give some observations on a rather unique and ingenious method in connection with the working of this material which came under our notice some little time ago with relation to the making of a pattern for a pipe connection known to the trade as a syphon bend (see Fig. 1), a description of which will be of interest. It may be mentioned here that for ordinary green-sand castings, the practice in pipe foundries is to make "shell" patterns for the pipe connections; that is, the pattern outside and inside takes the exact form of the casting, with this exception, that it is made jointed at the parting line in order that it may leave its own core.

This necessitates in all cases the making of two half patterns, one to right and the other to left hand, and it is to the making of these half shell patterns that our observations will be directed. It will be necessary, in order to appreciate the advantage to be gained by the method to which we wish specially to draw attention, to compare it with the method usually adopted in treating work

of this nature. In foundries where they make a speciality in pipes and their connections, it is the practice, without exception, to make the patterns for the connections in stucco, and to do this it is

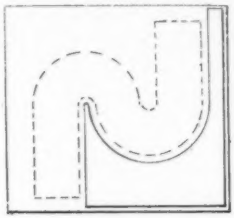

FIG. 6.

necessary to have two gauges, one called the "core gauge" (see Fig. 2), and the other the "thickness gauge" (see Fig. 3). These represent the inside and outside diameters of the pipe for which the connection is wanted.

These gauges are made of sheet malleable iron, or from a thin plate of cast

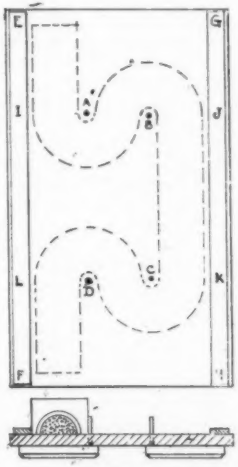

FIG. 7.

iron, the half-round cutting face being chamfered away at the back (as shown on full size section through A A, Fig. 4), leaving not more than $\frac{1}{32}$ part of an inch on the face.

After being filed to the diameter, this face must be finished with emery paper, and made perfectly smooth, to ensure a good surface on the stucco.

In pipe foundries the gauges are stocked for all the standard sizes of pipes; therefore, the same gauges are used for all patterns of connections required for that particular pipe for which they were first made; so that no time is lost in preparing gauges should a pattern be wanted for some particular connection for which there is no pattern. It is also necessary to have a wooden template, or guide strip, cut to the shape of the required connection.

This template is fixed on to a laying-down board, and the soft stucco is then laid on the board, and is formed into shape by the gauge when drawn along the contour of the template. The bock or core is first "run up," and when

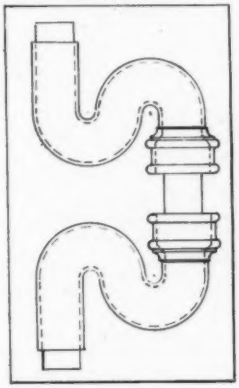

FIG. 8.

finished is given a coat of shellac varnish; it is then oiled before the thickness is "run up," the oil allowing the thickness to come away or "part" from the block.

Fig. 5 shows a laying-down board with guide strip in position, with the track of the gauge, indicated by dotted line, which, it will be observed, takes the form of one of the halves of the syphon bend which we have under discussion.

Now this is one of the most difficult patterns to be met with by the pattern-maker, in so far that there is an internal curve, A to B, to be overcome.

In working round this curve it is hardly possible to get a true curve at the point D, and when "running on" the thickness there is every chance of it "tearing off" at this point. In making the reverse hand, the guide strip is re-

moved from its present position, turned upside down, and fixed on another board, as shown on Fig. 6, and the same operation gone through; that is, the soft stucco is laid on the track indicated by the dotted lines, and the half-round gauge is "swept" round the contour of the guide strip, and in this way bringing the pattern into shape. The faucets (which are stocked in the same way as the gauges) are added to each of the respective halves, and the pattern is then ready to pass to the moulder. We will now describe the method to which we wish to draw attention, and it will be observed that not only can both halves of the pattern be "run up" at the same time, but the trouble of the internal curve entirely disappears.

The iron gauges and the laying-down board are required in this as in the other method.

The two halves (right and left) of the syphon bend are drawn down on the laying-down board (see Fig. 7). Two strips, E F and G H, are secured to the board, and pins, say ¼ in. in diameter, are fixed into the board at the centres, A B C and D, leaving a part projecting about 2 in. outside the board.

The soft stucco is placed on the track of the gauges which starts at E and drawn along the edge of the strip E F to I, when the other edge of the gauge comes against the side of the pin A, when it is held against it, and revolved until the other edge comes against the pin B; the gauge is then revolved on the pin B until the edge which revolved on pin A comes against the edge of the strip G H at J.

The gauge is then drawn along this strip from J to K, when it is revolved on the pin C and then on the pin D, and again on to the edge of the strip E F at L; it is then drawn along the strip and finished at F.

When the thickness has been run on, the ends are faced to the proper lengths, and the faucets placed in position; the pattern is then ready to pass to the moulder for the iron patterns, as shown on Fig. 8.

Hitherto, the question of how to overcome these internal curves which occur very frequently in stucco work, has been a matter of much concern to the pattern-maker, and those who have had experience with work of this nature will appreciate this means of overcoming the trouble. Even in work where circumstances do not permit using the latter method, the principles contained therein can be combined with the former method by fixing a pin at the centre of the internal curve; and while working the gauge round the internal curve of the guide strip, the other side of the gauge can be held against the pin.

In this way a true inner curve may be obtained. The arrangement herein described may, with advantage, be applied to other forms of stucco work, at the discretion of the pattern-maker.

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MOULDING ROPE PULLEYS.

By R. D. W.

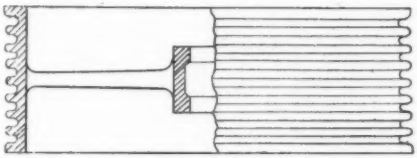
Various methods of moulding rope pulleys are in use in different foundries and localities, for each of which some advantage is claimed by those who use them. While a large number are made in certain districts, in others, such a job is seldom or never seen, therefore a description of two or three methods will, I think, be of interest to the trade.

The method we will deal with first is to form the mould by means of cores. In Fig. 1 is shown a part elevation and section of a 6 ft. rope pulley, with six arms and eight grooves, the plan appearing in Fig. 2. Two core boxes will be required, one to form the cores for the inside, the other for the outside. The first must be made the full depth of the pulley, taking in one arm and a corresponding part of the boss, also forming the print for the centre core. It is best made in three pieces, the two sides and a segment of the inside circumference, and can be fastened together by means of screws or bolts. The arm and the section of the boss can be fixed in position by means of pegs, which can be readily withdrawn when the core is rammed up. A plan of the core box is shown in Fig. 2. The core box for the outside can either be made with complete grooves, as shown in Fig. 3, or a frame can be made and the grooves struck up by means of a sweep. By the latter method a considerable saving of time can be effected in the pattern-shop, and the cores can be made quite as quickly and as good. In either case the box must be made the exact depth of the pulley to be moulded. Prodded grates for the cores can be cast in open sand. Another method is to make a core box to form a short section of a single groove, but this way requires a large

number of cores, and while the joints can be crossed better the cores take longer to make and place in position, making the method inferior to the full depth core method.

To mould the pulley a hole is dug in the floor the depth of the pulley, and a level bed made. A piece of wood is driven in the centre of the bed and the inside diameter marked out with a pair of trammels. The circle is then divided

FIG. 1.



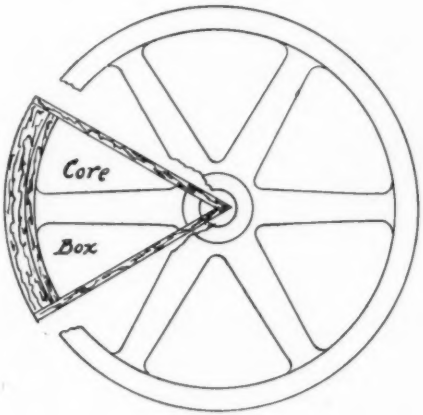


FIG. 2.

into six equal parts, lines being struck across to make six equal divisions or core spaces. Another bed is made on the shop floor, or a suitable joint board procured on which to place the core box which forms the cores for the inside of the pulley. Parting sand is applied, and a lifting plate—as shown in Fig. 4, and of which six will be required—placed on the bed or board. The core box is lifted on and the core rammed up in green sand, irons being placed in where necessary, and a bed of ashes laid under the arm, the vent from which can be brought away at the side of the core. The pegs, bolts, or screws are taken out, the box removed, and the arm and section of the boss withdrawn, the core being then lifted into its place on the bed previously prepared. The other cores are made and placed in position in a similar manner,

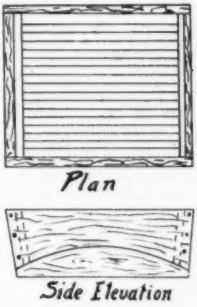


FIG. 3.

the joints in the boss being made up and the boss finished as far as possible before the last core is placed in position. The outside of the cores is next taken in hand and finished; care must be exercised to vent down to the ashes at the end of the arms, as the metal to fill the rim, having to run through the arms, they are liable

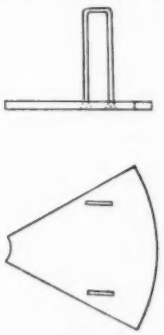


FIG. 4.

to scab unless properly vented; a further safeguard is to use a little better sand under the ends of the arms where the metal runs over. The inside of the pulley is now complete, with the exception of the centre core.

The cores which form the grooves should be ready, having been made a day or two previously, and dried in the stove.

They are now placed round the inside of the mould, being set by means of thickness woods. Sand is rammed behind them

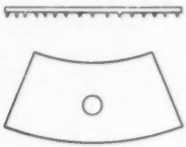


FIG. 5.

and strickled off to form a level joint round the pulley. The centre core is placed in the print and the boss covered by means of a small cast iron plate having holes made in for core print and runners. This plate requires a thin coat of loam, and must be dried and blacked. A covering is now required for the rim. If a suitable box part is available, it can be rammed up on a level bed on the floor, the pulley rim being marked out and risers rammed up. A space is left open in the centre of the box, so that the plate covering the boss can be reached. This top part is lifted, the portion covering the rim smoothed over, and it is placed on the mould, care being taken to see that the risers are over the rim and that it touches all the cores. The runners and risers are now made up, the box weighted down, and the job is ready to cast.

An alternative method of covering the rim is by means of plates or flat cores, made in segments of a circle, as shown in Fig. 5, or by a half, or even a full, circular plate, holes being made in for risers, and in the case of the large plates, staples cast in, or lugs cast on, for lifting purposes. These plates must be covered with loam, dried, and blacked. A box part can be placed over the plates and rammed up, pegs being placed in the holes provided for the risers. The box part is then weighted down as before mentioned. By

FIG. 6.

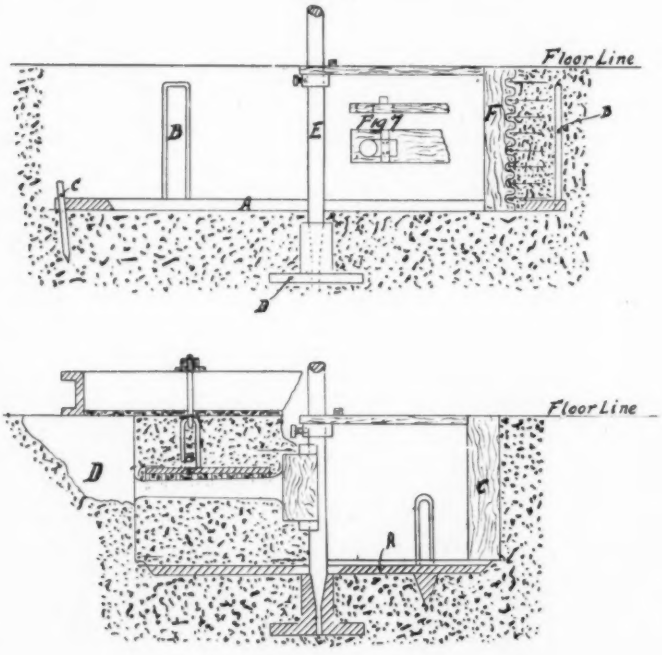


FIG. 8.

using these plates a box part can be dispensed with, and the plates and inside cores weighted down, though it will be well to remember that some additional weight will be required to make up for the weight of the box and sand.

A pulley with curved arms can be made in the same manner by using an additional lifting plate for each core and making a joint at the centre of the arms so that the pattern can be withdrawn, Also by the addition of splitting lugs and plates, split-pulleys can be made with equal facility. If preferred, all the cores can be dried in the stove and placed together in the same manner, thus making the job a dry sand one, but this is not really necessary for good work, and, further, as green sand does not resist contraction as much as dry sand there is less liability of fracture or of contraction strains being set up.

In Fig. 6 is a method of moulding the pulley rim in one piece. The tackle required is a lifting plate A with staples B cast in, and staking lugs C cast on. If the pulley is a deep one, it is also advisable to cast prods on the plate, especially if it is intended to dry this part of the mould in the stove. A seating D and a spindle E, with a loose collar and arm is required, also a wood pattern block F to form the grooves; this must have a piece of wood fastened to it to act as an arm and provided with a hole to fit over the spindle, the hole to be exactly in the centre of the pulley, and it should be cut away and a loose piece made to fit into the recess, as shown in detail in Fig. 7, so that as each section of the rim is rammed up the loose piece can be taken out and the block withdrawn.

To mould the rim the seating D is bedded in the floor in a hole dug deep enough for the pulley, the spindle placed in, and the loose arm attached. A straight board is fastened to the arm, and a level bed strickled off. The circumference of the pulley is marked out, and the plate A bedded on. The loose collar is now placed on the spindle, and the block, with arm attached, placed in position, the collar being fixed so that the arm is perfectly level. The outside is next rammed up, the grooves being sprigged, as shown, and vented, and a level joint made at the top. The loose piece is taken out, the block withdrawn and moved round, the process being repeated until the whole of the outside is complete, when the sand is dug away from the back and the plate lifted away, finished, and dried, if desired. If the plates are prodded, pieces of sheet iron can be placed against the prods, and the sand rammed to them, thus saving the labour of ramming the hole up and digging it out again.

The inside of the mould is formed by means of green sand cores in the manner previously described. When the inside is finished the rim is lifted back into its place and the mould covered by one of the methods described.

In shops where a full set of arms or sufficient loose arms are in stock, a method whereby the inside of the pulley can be lifted out can be adopted. For this purpose a plate rather less in diameter than the inside of the pulley is required. Lifting staples must be cast in, guide feet cast on, and a hole left in the centre, as shown at A in Fig. 8, which gives views of the mould in various stages. A spindle and seating is also required, and a cast-iron grid B prodded to clear the arms for the purpose of lifting the sand above the arms. A plain wood block, the contour of the inside, is made, and used in the same way as the block described above for the outside of the mould.

To prepare the mould, a hole is dug, the seating and spindle fixed, and the plate A bedded down level. A loose arm, with board attached, is fastened to the spindle, and a bed strickled off round the plate for the pattern block to rest on. The arm is then removed, the loose collar and plain block placed in position, the sand rammed to it, and a joint made at the top. The job is shown at C in Fig. 8 in this state. The block is moved round until the whole is rammed up, when we have a sand core box for the inside of the pulley. Sheets of paper can be laid round, or a little parting sand applied, and sand filled in and rammed until high enough for the arms and boss, which are bedded in to measurement or gauge. The ramming is continued, and a joint made in the centre of the arms, parting sand sprinkled on, the joint covered with a layer of sand, the grid B lifted in, and the ramming continued to the top, when a joint can be made and a level top rammed up, or a box part can be placed on, the grid fastened to it, as shown, and the ramming again continued until the box is rammed up, runners and risers being placed in their proper places, and the box staked. The sand is now dug away to the centre of the arms, as shown at D,

in Fig. 8, and the top part lifted away, a good lift being ensured by this means. The sand can now be dug away to the bottom of the pulley, the plate lifted out, placed to one side, and finished. If the level top method is adopted, of course the grid is lifted out separately, and in this case guide feet must be cast on the grid to ensure it going back into its exact position when the mould is closed.

The spindle is again placed in the seating, and the outside rammed up to the grooved block, as described in the previous method. When the outside is finished, the inside is lifted back into its place, cores inserted, and the top lowered on. If desired, the rim can be covered by means of plates, and the box part dispensed with, as already described. Good and accurate castings can be made by any of these methods, in either green or dry sand, the method adopted being chosen to suit the tackle and facilities available and the size of pulley to be moulded.

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SOME NOTES ON THE CHEMISTRY OF CAST IRON.*

By Mr. E. Houghton.

Having been asked only at the last moment, almost, to read a paper at this meeting, the writer has not had time to prepare and present very much original matter. As this, however, is a meeting of practical men, some notes on the various constituents of cast iron which represent the experience gained as a chemist in dealing with cast iron, may not be out of place.

What follows is not intended to be an exhaustive exposition of the constitution of cast iron, but rather a *résumé* of some points which have interested the writer from time to time.

The subject is divided for convenience under the heads of the chief constituents of cast iron.

Carbon.—This substance, whose presence in combination and alloy with iron is almost alone responsible for the range of metals, mild steel to cast iron, has naturally been the object of considerable attention at the hands of metallurgists. Much patient and careful work has been done in recent years in elucidating the problem of the mode of occurrence of carbon in steel, and, indeed, in this respect, our knowledge of steel may now be regarded as fairly complete.

To cast iron, however, on account of the complications arising from the presence of large quantities of other elements, no very considerable attention had been given until quite recently.

Now that our knowledge of steel has been brought to a state of comparative reliability, there seems no reason why the more difficult problems in connection with cast iron should not be proceeded with apace.

For example, the diagram designed by Roozeboom indicating the changes occurring in the condition of carbon during cooling from the molten state, requires amending in the case of grey castings to show the effect of the various elements in changing the position of the critical points.

There is a certain amount of information on these points, disseminated amongst current literature, but some graphical representation of it would be a very welcome adjunct to our means of studying cast iron.

The unreliability of the colour test for combined carbon in cast iron is well known, as often the whole of the combined carbon is not indicated by the test. This is particularly the case with iron which has received heat treatment, and is more obvious as the content of combined carbon increases towards white iron. Grey iron castings, normally cooled, are, however, practically free from the feature, in the writer's experience.

An analysis of cast iron may, indeed, soon be considered incomplete when the carbon is stated in terms of graphitic and combined carbon only, and some indication will be necessary, either analytically or micro-graphically, to show, not only in what form the combined carbon is present, but also to distinguish between the free carbon as graphite and as temper or annealing carbon.

The size of the grains of the graphite in cast iron has had a new importance given to it through the investigations of Professor Turner on this subject. According to Professor Turner's results, annealing carbon is that graphite which is sufficiently small to pass the 90 sieve. This finely-divided graphite is more desirable in a casting than the large

* Paper read before the British Foundrymen's Association.

flakes, as the latter develop lines of weakness in the iron.

I had the privilege of making the analysis in connection with the paper on "Cast Iron" read by Mr. H. Pilkington, M.Inst.C.E., now your President, at your last meeting.

In this work I soon found that not only was combined carbon present in more than one form, but that the graphite was present after heat treatment in a very fine condition, and much of the benefit derived from the method of heat treatment there described is, in my opinion, due to this finely-divided state of the graphite. Processes for the production of this finely graphitic structure, whether of heat treatment or otherwise, will probably play an important part in the future history of cast iron.

In judging a pig-iron for foundry purposes, however, the maxim is still true that the greater the ratio of the total amount of graphite to the total amount of combined carbon, the more valuable the iron.

Silicon.—From a purely chemical point of view, silicon is so closely allied to carbon that it would not be surprising to find a close relationship between them in the manner of their occurrence in cast iron. Indeed, graphitic silicon has long been sought for, and may ultimately be proved to exist, whilst in combined condition silicon also very closely resembles carbon.

The subject is somewhat difficult, and very little authoritative work has been done, or at least announced, so far as the writer knows, although it may be that some at least of our troubles may find explanation on these lines.

Mr. J. E. Stead, writing on Professor Sexton's Metallurgy of Iron and Steel under the heading "Heat Treatment of Grey Iron," notices two varieties of silicon in considering grey iron high in silicon, chilled from the liquid state, one kind of which gelatinises on solution in hydrochloric acid, whilst the other does not.

In examining samples of over-grey iron, mentioned by Mr. Pilkington in the paper just referred to, the writer has found indications of a similar nature in regard to the silicon. It is quite possible that the properties of such iron may be due to the condition of the silicon, or are more marked from this cause. This element is not uniformly high, however, as some analyses will show.

Analysis of Over-Grey Iron.

—	I.	II.	III.	IV.
	Per cent.	Per cent.	Per cent.	Per cent.
Total carbon	3.75	3.62	3.53	3.62
Graphitic carbon ...	2.85	2.90	2.95	3.37
Combined „	0.90	0.72	0.58	0.25
Silicon „	1.82	1.87	2.94	4.01
Sulphur „	0.007	0.008	0.007	00.22

The conditions under which this iron is produced are very interesting. The furnace is always working very hot, and the iron being run slowly down to the beds, apparently becomes chilled whilst fluid, and when cold presents a very wild fracture. Unfortunately, considerable variation is allowable in furnace conditions for the production of this metal, but there are certain fixed conditions, the main one of which is that the burden is always light, carrying an excess of coke. With this fixed condition, there is a certain amount of variation possible in the product of the furnace according to other variable conditions. If the slag be very limey (say 43.0 per cent. to 45.0 per cent. lime), then if the metal as tapped contains a normal amount of silicon (say 3.0 per cent. to 3.5 per cent.) the pig-iron will usually have a good No. 1 or No. 2 fracture. With the silicon under 3.0 per cent., the fracture will be wild and scattered, and the more so the lower the silicon contents. On the other hand, with a slag comparatively low in lime (say 35.0 to 40 per cent. lime), and a similar burden as regards fuel, two products are again possible.

If the silicon be over 4.0 per cent. the iron will be glazed, and if under 4.0 per cent. of good fracture. Under such conditions low silicon iron is not made.

The question thus resolves itself, more or less, round the silicon content, and it would seem that with rich, limey slags there may, under certain practical furnace conditions, not be sufficient silicon reduced to ensure all the carbon (or a sufficiently large proportion of it), to remain as graphite. The iron also carries a larger total carbon than is usual with the brand, and there is consequently a greater tendency to form combined carbon.

It may also be that a portion of what silicon is present is rendered incapable of acting upon the carbon, owing to the chilling of the metal in the liquid state, and thus increasing the effect.

This, and the microscopic examination,

are the lines on which probably further information can be gathered on this subject.

That there is something unusual in the condition of the elements in such iron is shown by the fact that remelting in a cupola does not remove the evil properties of the iron, and in all probability it will be necessary to remelt in air furnaces to a higher temperature than the original temperature at which the metal was tapped.

Mr. Pilkington, who is well known as an expert in blast furnace matters, has taken a keen interest in the matter for years, has made the subject his own, and will no doubt ultimately see the most interesting problem satisfactorily solved.

In a paper by Mr. A. E. Outerbridge, presented to the American Foundrymen's Association, the addition of ferro-silicon to the ladle is advocated, and very considerable gains in transverse strength and deflection are shown, as a few illustrations extracted from that paper will show.

Silicon added.	Size of ladle.	Transverse strength.	Deflection.	Alteration in strength.	Alteration in deflection.
		Lbs.		Per cent.	Per cent.
½ lb.	Hand ladle	2,265	.120		
None	,,	2,150	.112		
	Gain ..	110	.008	5.10	7.14
½ lb.	Hand ladle	2,330	.143		
None	,,	1,893	.110		
	Gain ...	437	.033	23.80	30.00
1 lb.	200 lb. ladle	2,370	.139		
None	,,	2,050	.118		
	Gain	320	.021	15.60	17.80
1 lb.	200 lb. ladle	2,178	.128		
None	,,	2,000	.119		
	Gain ..	178	.009	8.90	7.50

Mr. Outerbridge, however, points out that the use of ferro-silicon in the ladle may be better than the addition of extra silicon to the mixture on the cupola stage, as the silicon added as ferro-silicon readily abstracts any oxygen from the molten iron which may have been taken up from the blast in the cupola. Such oxygen, it is well known, has a very detrimental effect on the iron, and is the cause often of trouble which is attributed to other causes.

The writer has made some experiments with ferro-silicon, which, whilst not at all exhaustive, may be interesting in this connection.

In the first two instances quoted, the cupola was running on a light-coloured slag, whilst the last two instances are from a cupola on a dark slag.

Character of slag.	Pure silicon added.	Quantity of metal used.	Transverse strength.	Deflection.	Alteration in strength.	Alteration in deflection.
			Lbs.		Per cent.	Per cent.
White	½ lb.	50 lbs.	3,160	.310		
	None	,,	3,350	.333		
		Loss	190	.023	5.7	7.0
White	½ lb.	100 lbs.	3,000	.320		
	None	,,	3,300	.350		
		Loss	300	.030	9.1	8.6
Dark	½ lb.	75 lbs.	3,550	.325		
	None	,,	3,330	.315		
		Gain	220	.010	6.6	3.1
Dark	½ lb.	100 lbs.	2,430	.330		
	None	,,	2,100	.300		
		Gain	330	.030	10.60	10.0

The results are interesting rather as a comment upon the statement by Mr. Outerbridge that the good results may be due to the extraction of oxygen from the metal, than as decisive for or against such additions.

In the first case, the iron being melted in a hot cupola on a light-coloured slag, indicating a sufficiency of coke and limestone for fluxing, the conditions are such as to reduce the tendency to absorb oxygen to the minimum, whilst in the second case these conditions are absent; in the former case the addition of ferro-silicon reduces the strength and deflection, in the latter increases them, and it would seem as if there were some connection between the two.

It may be that since American iron is lower in silicon than in English brands, and that higher melting ratios are more common there than here, combined with the use of stronger blast, some considerable absorption of oxygen is a constant occurrence in their practice.

Even if this be so, it is a question whether it would not be more economical to work with slightly lower melting ratios, with more flux on the charge, than to incur the expense for ferro-silicon to more than cover any economy obtained.

Manganese and Sulphur are so connected together in the relation to cast iron that they may for our purpose be considered together.

The presence of manganese in quantity in iron has two principal effects, namely, to increase the power of the metal to absorb carbon, and to decrease the amount of sulphur held by the iron.

Whilst connected as a chemist with the manufacture of ferro-manganese and spiegels, the writer observed that in every case examined sulphur was practically absent in these metals.

The following typical analyses will indicate both the properties referred to:—

	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Manganese	30.00	40.0	50.0	60.0	70.0	80.0
Carbon ...	5.4	5.6	5.8	6.2	6.5	6.8
Sulphur ...	0.005	0.005	0.005	trace	trace	trace

The usual effect of manganese is to harden castings and to increase the shrinkage, but these effects can generally be neutralised by judicious adjustment of the silicon contents, whilst its power to make the metal more fluid and thus reduce the number and size of blowholes is of great use.

Sulphur, as is well known, tends to cause the carbon to assume the combined form, and thus produce hard and brittle castings; it is now acknowledged to be present in cast iron as manganese sulphide, if sufficient manganese is present to satisfy the whole of the sulphur, if not the balance is there as sulphide of iron.

The sulphide of manganese being very fluid, has a tendency to float to the top, more or less, during cooling.

As this occurs on a large scale, it is quite possible to use manganese in the form of ferro-manganese, or spiegel, as a softener, by removing the sulphur from the iron, and thus at the same time removing the effect of the sulphur on the condition of the carbon.

This is only possible, however, in the case of very common iron.

Some very interesting experiments showing the effect of the addition of ferro-manganese to common iron, are described by Mr. T. E. Holgate, A.R.S.M., of Darwen, in a paper on this subject read before the Staffordshire Iron and Steel Institute in 1892, and the following table is compounded from figures given in that paper:—

—	I.			II.	
	Original iron.	Melted with 16 per cent. Spiegel to give 1.80 per cent. in mixture.	Melted with 80 per cent. ferro mn. to give 1.80 per cent. in mix ure.	Original iron.	Melted with 80 per cent. ferro mn. to give 9.0 per cent. mn. in mixture.
Manganese	White. 0.491	Grey. 1.22	Grey. 1.12	White. 0.22	Grey. 6.87
Sulphur ...	0.170	0.057	0.065	2.50	0.056

Even without such external additions, the presence of very normal quantities of manganese (say 1.00 per cent.) will ensure the expulsion of some of the sulphur under favourable circumstances, and more advantage might be taken of the fact than is the practice to-day, especially where the foundry is worked in connection with a blast-furnace plant and direct metal may be used.

Considerable quantities of sulphur might be eliminated by running the metal first of all to a receiver or mixer of suitable size and heated in a similar manner to that adopted in steel works practice.

The results obtained at Cargo Fleet and published by Mr. G. A. Wilson in a paper on the Talbot process* are very interesting in this respect.

The steel furnaces at this plant were ready before the mixer was finished, and the metal was taken direct from the blast furnaces to the steel furnace.

The sulphur contents in the iron before and after the mixer was used compare as follows:—

Prior to use of mixer ... Sulphur, .10 to .15%
After " " ... " 0.019 "

thus showing a very considerable reduction.

Even in ordinary cases, where metal has had to be held for a considerable time before casting, considerable reductions have taken place.

The two following instances, which have come under my observation, and in which the metal had to be held for about one hour after tapping, illustrate the same thing:—

—	I.		II.	
	As tapped.	After 1 hour.	As tapped.	After 1½ hours.
Sulphur ...	0.070	0.038	0.060	0.030
Manganese	1.00	0.80	1.20	1.00

If the metal had passed through a mixer, probably better results might have been obtained.

Phosphorus, in whatever quantity and form it is charged into the blast furnace, is found entirely in the pig-iron, and, indeed, ferro-phosphorus up to 20 per cent. phosphorus has been made in the

* West of Scotland Iron and Steel Institute.

blast furnace in this country to the writer's knowledge.

—	I.				II.		III.		IV.		V.		VI.	
	Pig-iron.	Large button. Mottled.	Soft crystals ex button.	Small shot. White.	Pig-iron.	Small shot. White.	Pig-iron.	Small button. Grey.	Pig-iron.	Small button. Grey.				
Silicon ...	1.026	0.513	—	—	—	—	—	—	—	—	—	—	—	—
Sulphur	0.150	0.055	—	—	—	—	—	—	—	—	—	—	—	—
Manganese	0.800	0.795	—	—	—	—	—	—	—	—	—	—	—	—
Phosphorus	1.460	3.960	2.76	4.88	1.44	5.73	1.35	2.88	1.42	2.032	—	—	—	—

It is present in cast iron, partly as phosphide of iron, and partly in solid solution in the iron.

The term solid solution is not very easy to understand to those who are not familiar with the work which has been done upon steel with the aid of the microscope, but an authoritative explanation of these terms may be found elsewhere, notably in Mr. Stead's paper on "Iron and Phosphorus" (Iron and Steel Institute, 1900), and we need not explain here.

The phosphide can be readily detected on an etched specimen of the polished iron, with a little practice; or without etching, by what is termed heat tinting. In this process the specimen is slowly heated, and the succession of tints assumed by the constituents noted.

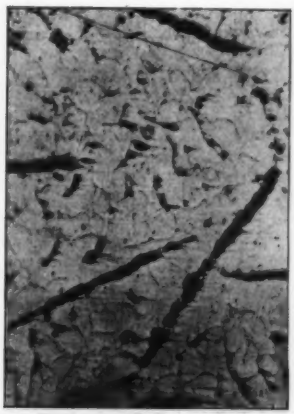

FIG. 1.
SHEEPBRIDGE NO. 1 PIG, UNETCHED. SHOWS GRAPHITE AND PHOSPHIDE EUTECTIC, WHICH IS IN RELIEF. × 60 DIA.

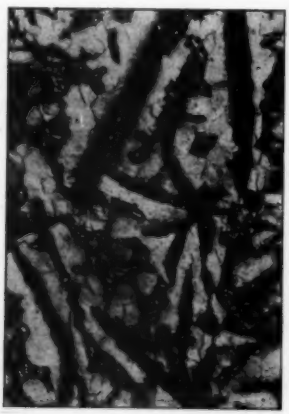

FIG. 2.
SHEEPBRIDGE NO. 1 PIG ETCHED WITH PICRIC ACID. SHOWING GRAPHITE, FERRITE, AND THE PHOSPHIDE EUTECTIC. × 90 DIA.

FIG. 3.
SHEEPBRIDGE NO. 3. PICRIC ACID ETCHED. GRAPHITE, FERRITE, AND PHOSPHIDE EUTECTIC. × 60 DIA.

In this way, when cementite has assumed a red colour, phosphide of iron has a pale yellow tint, and on continuing the phosphide at one period, becomes salmon coloured. This salmon tint is distinctive of phosphide of iron.

The above three micrographs of Sheepbridge Foundry iron, published in a paper on the "Micro-Structure of Cast Iron"

by Mr. O. F. Hudson, A.R.C.S. (Staffordshire Iron and Steel Institute, 1905), show the presence of the eutectic or mother liquor containing the phosphorus quite clearly, and are reproduced by kind permission of Mr. O. F. Hudson and the Staffordshire Iron and Steel Institute.

Phosphide of iron is very fluid, and on this account helps very materially in lowering the melting point of cast iron, as it melts considerably before the bulk of the iron. In virtue of this property, globules of metal are occasionally found in iron containing much more phosphorus than the rest of the metal. Such accumulations of phosphorus have been noticed by Dr. Moldenke, in America, and by Mr. Stead also in this country.

Some months ago this matter was brought to my notice by Mr. P. Munnoch, who had found buttons containing very considerable percentages of phosphorus occurring in cast iron.

Some of these figures are, I understand, to be published by Mr. Stead shortly, and will be found to be very interesting.

For some time I was unable to obtain any specimens containing over 2 per cent. phosphorus, but during the last few weeks I have been particularly fortunate in finding several very interesting buttons in pig-iron.

All my specimens are from pig-iron. None of them were very large; some, indeed, quite small. The analyses are given on page 36, so far as I have had time and material.

Button No. 1 was found embedded in a sample of pig-iron whose fracture perhaps merits description.

When the pig was broken, the inside was found quite rusty and dark coloured, the only bright metallic portion being a thin layer round the exterior. The iron had been watered whilst still very hot, and a crack had been produced in one side, through which, apparently, water had entered, cracking the interior of the pig, whilst leaving a shell of metal only round the outside. In the centre of the pig was the button firmly embedded like a fossil, and not occurring, as in other cases, in blowholes or near the surface.

A microscopic examination of these buttons would no doubt yield some very interesting results, and it is to be hoped that Mr. Stead will deal with this side of the question in taking the matter up.

At present, microscopic outfits are not recognised institutions in most plants in this country, but at the present rate of progress in this branch of the study of cast iron the day will not be far distant, I think, when they will be the rule instead of the exception.

When one considers the matter closely, the microscopic examination of cast iron is merely a modification of grading by fracture.

The only difference is that the power of the human eye, which has its limitations, is reinforced so that the fracture may be examined as closely and minutely as possible.

It is a trite and true saying that if a thing is worth doing at all it is worth doing well, and the advocates of judging and grading iron by fracture should be amongst the first to welcome microscopic examination also.

There is no doubt that in many instances in which doubt still remains, in spite of close analytical study, the microscope would be of great service, but before such equipments can be of practical use a considerable amount of patient routine and trial work will be necessary, so that the operator may know and have confidence in his apparatus and results. It is, therefore, folly to wait until results are actually required before commencing this work.

In conclusion, I am much indebted to my employers, the Sheepbridge Coal and Iron Company, and to Mr. Pilkington, for kindly allowing me to use in certain cases data obtained in their employment, and for assistance and suggestions from time to time.

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A BALLOT on the question of federation has been taken during the past month by the members of the Friendly Society of Ironfounders of England, Ireland, and Wales, the Society of Ironmoulders of Scotland, the Welsh Ironfounders, the Plate Machine Moulders, the National Stove Grate Workers, the Core Makers and Metal Mechanics, the Journeymen Brassfounders, and the Scottish Brassworkers' Trade Unions.

THE ENGINEERING STANDARDS COMMITTEE have issued three complete tables of British standard screw threads. The first table contains particulars of Whitworth threads for sizes from $\frac{1}{4}$ in. in diameter, up to 6 in. in diameter; table two is similar, with the exception that it is for British standard fine screw threads, instead of Whitworth. The third table is for British standard pipe-threads, from $\frac{1}{8}$ in. up to 18 in. in diameter.

TRADE TALK.

MESSRS. BARRY, HEAD & COMPANY have removed to 110, Cannon Street, London, E.C.

MESSRS. E. J. WITCOMBE and C. H. PYM, engineers, Bristol, have dissolved partnership.

THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED, have closed their Belfast branch office.

RENNIES' STEEL CASTINGS COMPANY have removed to new works at Tollcross Park, Tollcross, Glasgow.

THE CHURCH IRON WORKS, Ince, have been offered for sale by public auction, but were withdrawn at £4,300.

THE FAIRFIELD SHIPBUILDING AND ENGINEERING COMPANY have issued £250,000 "A" mortgage debenture stock at par.

MESSRS. J. I. THORNYCROFT & COMPANY have denied a rumour that they were about to give up their Basingstoke works.

MESSRS. C. H. BUTTERWORTH and E. BUTTERWORTH, iron founders, Bury, trading under the style of Butterworth Bros., have dissolved partnership.

OPERATIONS have been started at the new works of the Gilbert Little Company, Limited, Bradford, with extensive contracts for coal-conveying plant.

YATES, HAYWOOD & COMPANY, LIMITED, of Rotherham, have appointed Mr. J. Brown, 50, Wood Street, Liverpool, as their sole Liverpool and district agent.

FRASER & CHALMERS, LIMITED, have made arrangements to continue making the engines built by the late Belfast firm of Victor Coates & Company, Limited.

MESSRS. JOSEPH EVANS & SONS, Wolverhampton, have appointed Mr. J. M. Gibbons, of Oxton, Birkenhead, as their Lancashire and North Staffordshire agent.

MESSRS. WILLANS & ROBINSON, of Rugby, who some time ago adopted the metric system, have now joined the British Weights and Measures Association.

THE ST. GEORGE'S IRON WORKS, LIMITED, Hulme, Manchester, have acquired the business of Messrs. H. Wren & Company, London Road Iron Works, Manchester.

A DISSOLUTION of partnership is notified in connection with Messrs. J. Swallow and E. C. Watkins, engineers, etc., St. Helens Junction, Lancashire, who traded as W. Neill & Son.

THE shipbuilding yard and engineering works at Kelvinhaugh of Messrs. Shearer & Sons, are at present in course of being dismantled prior to the firm removing to new premises at Elderslie.

MESSRS. GUEST & COMPANY have given up their iron works at Cradley Heath, and in future will confine their whole attention to their nail and horseshoe works at Halesowen.

THE BLAKE BOILER, WAGON AND ENGINEERING COMPANY, LIMITED, of Darlington, are now working the plant formerly belonging to the Darlington Wagon and Engineering Company.

MESSRS. I. & J. HYMAN have acquired the business of the late Mr. D. Hyman, scrap-iron and machinery dealer, and have removed to Thornhill Bridge Wharf, Caledonian Road, King's Cross, London, N.W.

THE BLASBERG ENGINEERING COMPANY, 78, Cross Street, Manchester, have been appointed sole British and Colonial agents for the manufacture and sale of water coolers, etc., on the Blasberg patent system.

NEGOTIATIONS are in progress to form an association amongst Scottish makers of forgings, with the object of checking price-cutting and establishing uniformity in the tests of steel required by consumers.

AT a meeting of the shareholders of W. A. Baker & Company, Limited, iron-founders, etc., Newport, held during the month, the liabilities were given as £79,500, and the assets were estimated at £115,000.

A DISSOLUTION of partnership is notified in connection with Messrs. M. T. Medway and F. J. Handford, Cheapside, London, E.C., and Rolt Street, Deptford, S.E., who traded under the style of Medway's Iron Company.

MR. ARTHUR CHAMBERLAIN has purchased the undertaking and assets of Tubes, Limited, exclusive of the Credenda and Star land and buildings, for £54,000, and has formed a new company. The capital is £100,000.

MR. J. R. EDWARDS, 150, Wool Exchange, Coleman Street, E.C., has been appointed London agent for W. Edwards & Son, Limited, engineers, of Wolverhampton, and the Eagle Edge Tool Company, Wolverhampton.

THE METROPOLITAN RAILWAY COMPANY has accepted the tender of Messrs. Row-

land, Carr & Company, 6 and 8, Lime Street Square, London, E.C., for the supply of cast-iron socket pipes and fittings for 12 months.

At the Newcastle Bankruptcy Court the public examination has been held of John Craik, trading as Craik Bros., engineers. The liabilities were returned at £148 16s. 1d., and the assets at £3 19s. 8d., the deficiency being £144 16s. 5d.

Mr. D. Crawford, 1, Metal Exchange Buildings, Whittington Avenue, E.C., has been appointed London agent for Messrs. J. Purden & Sons, makers of forgings, Glasgow, and for the Victoria Iron and Steel Company, Limited, Coatbridge.

Mr. A. F. Brewster, maker of the "Sperling" lock nut; Hadfield's Steel Foundry Company, Limited, Sheffield; and Messrs. T. & T. Vicars, engineers, Earlestown, Newton-le-Willows, have been elected members of the British Chamber of Commerce in Paris.

The Davis Gas Stove Company, Limited, intimate that the businesses of the Diamond Foundry, Falkirk, and the Langley Foundry, Luton, have been incorporated, and are carried on at the New Luton Works, under the style of the Diamond Foundry, Luton.

The Prevention of Corruption Act, 1906, which was passed to prevent an agent accepting any secret commission in relation to his principal's affairs or business, and likewise to stamp out bribery and corrupt acts, of every description, came into force on January 1.

Mr. Frank Robinson, lately of the United States Steel Products Export Company, has been appointed sole agent for Birmingham and the Midlands for the Ebbw Vale Steel, Iron and Coal Company, Limited, with offices in the Exchange Buildings, Birmingham.

Alex. Turnbull & Company, Limited, of the St. Mungo Works, Bishopbriggs, Glasgow, have taken over the business of the Harrison Engine Company, Limited, Salford, Manchester. The business will be transferred to Bishopbriggs.

The business of Jessop & Appleby Bros., Limited, of Leicester and London, has been amalgamated with that of the Glasgow Electric Crane and Hoist Company, Limited. The new firm will trade under the style of Appleby's, Limited, with head offices at 56, Victoria Street, London, S.W.

Samuel Fox & Company, Limited, have had erected at their Stockbridge Works, near Sheffield, by W. & T. Avery, Limited, of Birmingham, one of their latest pattern automatic self-indicating tram weighing machines. The machine is self-contained, and is fitted with Avery's patent automatic self-indicating steelyard.

Mr. J. F. Melling, of Leeds and Sheffield, who has been appointed London agent for Messrs. William Jessop & Sons, Sheffield, has disposed of his business to Messrs. G. Bradshaw & Company, iron merchants, Manchester, who will continue the business under the style of J. F. Melling & Company, Limited. Mr. Melling's offices are at 3, Victoria Street, Westminster, S.W.

W. & T. Avery, Limited, have made an interesting departure at their Soho Foundry, Birmingham, by forming amongst the younger employés an air-gun club. The firm supplied the necessary air guns, etc., and the idea has become so popular that at present there are ten clubs at the Soho Foundry. The scheme financially assists the works sick club, as the pellets used in the guns have to be purchased from the secretary of the club.

DEATHS.

Sir Edward Reed, formerly Chief Constructor of the Navy, aged 76 years.

Mr. R. D. Leslie, the Secretary to the Scottish Iron Trade and Shipbuilding Employers' Association.

Mr. Henry Holdich, for many years chief chemist for the Wigan Coal and Iron Company, at the age of 61 years.

Mr. R. Yates, head of the firm of Yates & Sons, iron and brass founders and machinists, of Malton, aged 65 years.

Mr. D. W. Jennings, of Curthwaite, Cumberland, at the age of 85 years. The deceased gentleman helped to found the Lowca Engineering Works, Whitehaven.

Mr. H. K. Peace, chairman and managing director of W. K. & C. Peace, Limited, manufacturers of crucible cast steel, edge tools, etc., Sheffield, aged 61 years.

Mr. J. Powell, who 66 years ago went to Birmingham, where he started in business as a smith, and afterwards bought the business of Hill's anvil and smiths' tool manufactory.

NEW COMPANIES.

DELTA ENGINEERING SYNDICATE, LIMITED.—Capital £5,000.

GLASGOW STEEL ROOFING COMPANY, LIMITED.—Capital £15,000.

DREWRY CAR COMPANY, LIMITED.—Capital £2,000, in £1 shares.

BRITISH GAS FURNACE AND TOOL COMPANY, LIMITED.—Capital £1,000.

GOODWIN, BRUCE & GOVAN, LIMITED.—Capital £10,000, to acquire the Blantyre Foundry, Blantyre.

PHILLIPS & HINE, LIMITED.—Capital £6,000. Registered offices: Toledo Stamping Works, Aston Brook Street, Birmingham.

GOODBYS, LIMITED.—Capital £3,000, to acquire the business of engineers carried on at Hunslet Mills, Leeds, as J. Goodby & Company.

SOLWAY ENGINEERING AND SHIP REPAIRING COMPANY, LIMITED.—Capital £3,000. Registered office: Irish Street, Maryport, Cumberland.

BRAMLEY ENGINEERING COMPANY, LIMITED.—Capital £25,000, in £1 shares. Registered office: Nenconner Lane, Bramley, Leeds.

SPEN VALLEY IRON AND STEEL WORKS, COMPANY, LIMITED.—Capital £2,000. Registered office: Russell Street, Heckmondwike, York.

OLLENDORFF & CLARKSON, LIMITED.—Capital £12,000, to carry on the business of engineers. Registered office: 163, Hope Street, Glasgow.

NUNAN'S ENGINEERING COMPANY, LIMITED.—Capital £35,000, in £1 shares. Registered office: Spencer House, South Place, Finsbury, E.C.

GRICE'S GAS ENGINE COMPANY, LIMITED.—Capital £20,000, to purchase the gas engine department of the business of William Grice & Sons.

QUEENSTOWN DRY DOCKS, SHIPBUILDING AND ENGINEERING COMPANY, LIMITED.—Capital £80,000. Registered office: Victoria Dock, Passage West, Cork.

ROBGREY & COMPANY, LIMITED.—Capital £10,000, to carry on the business of engineers. Registered office: 4, Suffolk Street, Pall Mall East, S.W.

COCHRANE & COMPANY, LIMITED.—Capital £100,000, to acquire the business carried on at Woodside Iron Works, Dudley, as Cochrane & Company.

ALBERT DOCK ENGINE WORKS, LIMITED.—Capital £12,000, to take over the business carried on at Albert Dock, East Ham, as the Albert Dock Engine Works.

PEARSON, SONS & COMPANY, LIMITED.—Capital £6,000, to carry on the business of engineers. Registered office: 107, Cathcart Street, Kingston, Glasgow.

W. NEILL & SON, LIMITED.—Capital £15,000, to acquire the business carried on at the Bold Iron Works, St. Helens Junction, Lancs., as W. Neill & Son.

F. STREET & COMPANY, LIMITED.—Capital £50,000, to carry on the business of engineers, etc. Registered office: Portland House, Basinghall Street, E.C.

WALSH & CLARK, LIMITED.—Capital £2,000, to acquire the engineering business carried on by Walsh & Clark. Registered office: Ings Mills, Guiseley, Yorkshire.

RIPPINGILLE MANUFACTURING COMPANY, LIMITED.—Capital £7,500, to acquire the business of manufacturers of stoves, iron, steel, and brass castings, etc., carried on at Birmingham, as the Rippingille Manufacturing Company.

Ganister, Cupola Blocks, Fire Bricks,

Fire Clay.

Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.

Steel Moulders' Composition, Silica Cement.

J. GRAYSON LOWOOD & Co., Ltd.,

DEEPCAR, nr. SHEFFIELD.

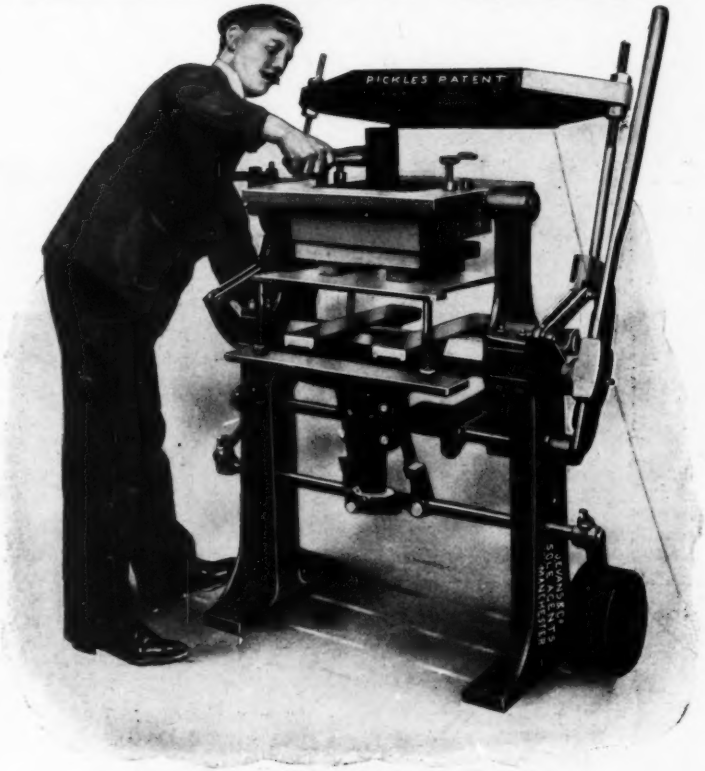
Telegrams: "LOWOOD, DEEPCAR."

NEW MOULDING MACHINE.

PICKLES' PATENT.

ASK FOR LIST AND FULL PARTICULARS.

COMPLETE FOUNDRY EQUIPMENT.



JAMES EVANS & CO.,

Britannia Works, MANCHESTER.

TELEGRAMS: "LADLES, MANCH STER." "BLACKINGS, GLASGOW." TELEPHONE: 2207, MANCHESTER. 3185, BRIDGETON, GLASGOW.

PERSONAL.

MR. A. IZATT has been elected a director of the Bengal Iron and Steel Company, Limited.

MR. T. L. FELLOWES, Humber Bank Iron Works, Hull, is retiring from active business.

THE RIGHT HON. J. E. ELLIS, M.P., has resigned his office of Under-Secretary of State for India.

THE late Sir Richard Tangye, chairman of Tangye's, Limited, left estate of the gross value of £226,319 6s. 2d.

MR. R. HALL, managing director of Robert Hall & Sons, Limited, Bury, has been made a J.P. for the borough.

MR. E. CARLISLE, Cumberland manager for Messrs. Cammell, Laird & Company, has been made a J.P. for the county.

MR. J. J. WELCH, manager of Messrs. Cammell, Laird & Company's shipbuilding department at Birkenhead, has been appointed professor of naval architecture at the Armstrong College, Newcastle-on-Tyne.

WHY BUY NEW CUPOLAS?

When you can have old ones converted, at small cost, by introducing

HIGHAM'S HOT BLAST PROCESS.

A Saving is effected in Coke of at least 25% on small furnaces.

I will adapt existing Cupolas to my process, allow a month's free trial, and if any dissatisfaction be expressed at the results, restore the cupolas to their former condition.

JAMES HIGHAM, Iron Founder,

BROOM LANE, LEVENSHULME, MANCHESTER.

ELDERS FOUNDRY COKE

As supplied to the British . . Admiralty Dockyards.

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time.

We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blow-holes and other defects, than we formerly did.

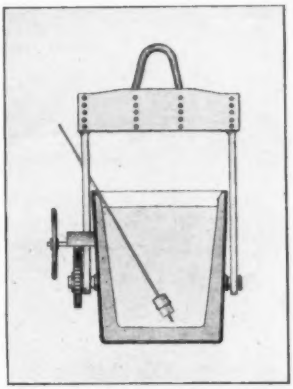
From MOUNTFORT PHILLIPS & Co., Llantrissant.

Llantrissant, October 25th, 1904.

In reference to the Foundry Coke you have been supplying us with for the last six months, we have very great pleasure in letting you know that it has given every satisfaction, and that our Works Manager and Workmen give it the highest praise.

Elders Navigation Collieries, LTD. Cardiff.

PREVENTION OF BLOWHOLES IN CAST IRON.



A tin of our special compound fixed on a rod is held at bottom of ladle as shown; a strong re-action being thereby set up frees the iron from gases and impurities, which rise to the top.

RESULT: A denser casting of finer grain with increased strength.

For Particulars apply to—

THERMIT LIMITED,

27, MARTIN'S LANE, CANNON STREET,

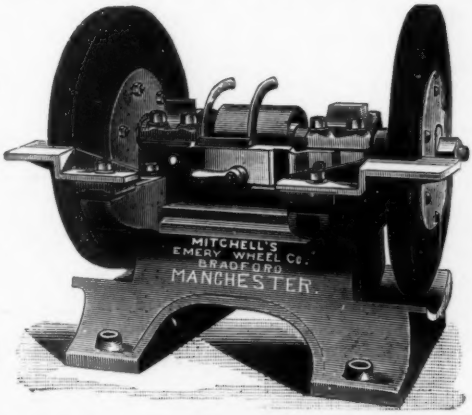
Telephone—3749 Central.
Telegrams—"Fulmen," London.

LONDON, E.C.

MACHINES For all Purposes. **WHEELS.**

Complete with Emery or Corundum Wheels from **£2** upwards.

Special Machines Designed.



Emery or Corundum from 1 in. x $\frac{1}{8}$ in. to 50 in. x 12 in.

Enquiries solicited.

MITCHELL'S EMERY WHEEL Co.,

Mill Street, Bradford, MANCHESTER.

Also at LONDON, GLASGOW, and BELFAST.

LISTS FREE.

PRICES OF METALS.

The following table shows the approximate latest prices and position of stocks of metals during the past two years :—

METALS.	1905-6.	1904-5.
Iron—Scotch pig warrants ... ton	*67/0	—
—Middlesbro' warrants ... ... ton	60/7½	51/7½
—W.C. M/nos Bessemer ... ... ton	83/0	72/6
—Stock, Scotch, Jan. 3 ... tons	5,286	15,600
Copper—Chili bars, GMB ... ... ton	£103 5 0	£80 7/6
—Stock, Europe & afloat... ... tons	16,924	12,983
Tin—English ingots ton	£191 5/0	£166 10/0
—Straits ... ton	£188 5/0	£163 0/0
—Stock, Ldn. Hlnd and aflt ... tons	13,118	13,501
Lead—English pig ton	£20 2 6	£17 16/3
Spelter—Ord. Silesian ... ... ton	£27 15/0	£29 6/3
Quicksilver (75lb.) bottle	£7 0/0	£7 5/0
Antimony—Regulus ... ... ton	£114 0/0	£61 0/0

*Settlement price.

CASTINGS.

In the Cleveland district the following are the nominal rates current for castings :—

	£ s. d.		£ s. d.
Columns (plain)	7 0 0	to	7 5 0
Pipes, 1½ to 2½ in.	5 12 6	to	5 15 0
,, 3 to 4 in....	5 5 0	to	5 7 6
,, 5 to 8 in.	5 2 6	to	5 5 0
,, 10 to 16 in.... ...	5 2 6	to	5 5 0
,, 18 to 24 in.... ...	5 2 6	to	5 5 0
Chairs	4 5 0	to	4 7 6
Floor plates (open sand)	3 15 0	to	3 17 6

SCRAP.

The quotations for scrap, subject to market fluctuations, are as follows: — Heavy wrought (mixed), £3 5s.; light wrought, £1 15s.; heavy cast, £2 12s. 6d.; all per ton f.o.b., London. Copper (clean), £95; brass (clean), £67; lead (usual draft), £18 15s.; tea lead, £17; zinc, £22 15s.; all per ton delivered merchant's yard.

SILICA FIRE BRICK Co.,

OUGHTIBRIDGE.

GROUND GANISTER,

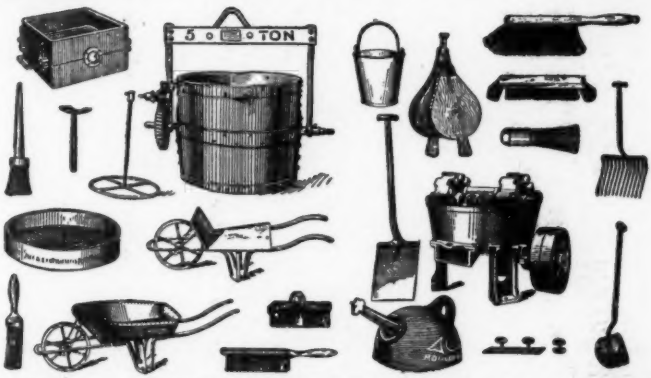
Wet or Dry.

Silco Cupola Bricks, 90 % Silica.

Better than Fire-clay Bricks for Cupolas.

Established 1863.

Jas. Durrans & Sons,



PHŒNIX WORKS, PENISTONE, Near Sheffield.

Manufacturers of all

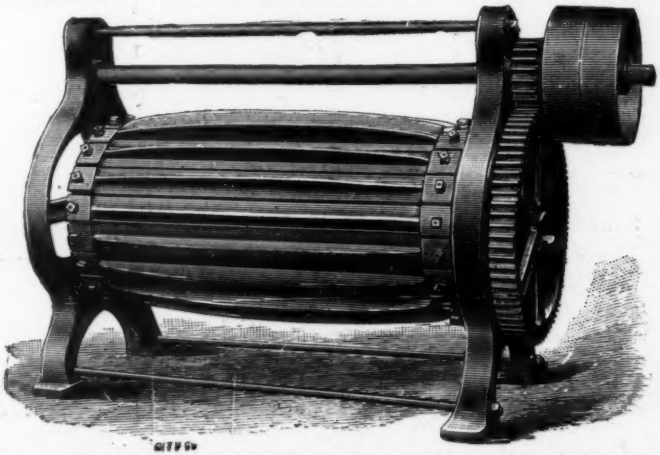
FOUNDRY EQUIPMENTS,

Composition Black Lead,

Plumbago, Core Gum, White Dust, and Coal Dust.

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, &c.

IMPROVED FOUNDRY RATTLER or FETTLING DRUM.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

"Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD."

The most successful Foundry Specialities are

THE PIFTIN SPECIALITIES.

The Piftin Specialities are in universal favour with Founders both large and small, and are in constant use throughout the World.

The reason of their great and continued success is that each Speciality handled by us is proved to be a practical success *before* it is placed on the market.

It costs us a lot of money, time, and trouble to ensure this, but then it enables us to fully satisfy our buyers, and we thereby gain what we aim at—The repeat orders of our numerous clientele, both at Home and Abroad.

If, therefore, you are wanting anything for your Foundry, you should get the best of its kind, which is the *PIFTIN.*

The Piftin High Pressure Blower

Over 80 have been supplied to H M. Government.

The Piftin Portable Mould Drier

In use throughout the World, including the principal British and Continental Foundries.

The Piftin Sand Renovating System

Saves 80% of the yearly sand Bill.

The Piftin Sand Mixing Machine

The most efficient machine on market.

The Piftin Sand Blast Machinery

Adapted for all purposes.

Up-to-date in every respect. The most efficient, most simple, and most easily worked of any apparatus on the market. Saves the entire cost in the first few months.

For further particulars apply to

PIFTIN LIMITED,

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PLEASE NOTE NEW ADDRESS. LONDON, E.C.

NOTICE.

CARNEGIE RESEARCH SCHOLARSHIPS.

THE Council of the Iron and Steel Institute will shortly proceed to award Research Scholarships founded by Mr. Andrew Carnegie.

Candidates, who must be under 35 years of age, must apply before February 28th, on special forms to be obtained from BENNETT H. BROUGH, Secretary, Iron and Steel Institute, 28, Victoria Street, London, S.W.

FOR SALE AND WANTED.

FOR SALE, "ROOT'S" PATENT BLOWERS.
No. 1a size, "Allday's," 6 in. outlet, £18.
No. 1 ,, ,, 7 in. ,, £19.
No. 2 ,, "Thwaites," 8 in. ,, £20.
with Engines and Boilers to drive.
Address J. LIGHT, Wolverhampton.

FOUNDRY SAND and LOAM MILLS, Tumbling Barrels, Weighbridges.—Before ordering get particulars and prices from us.—LAURIE & CO., Union Passage, Birmingham.

TO BRASS FOUNDERS & ENGINEERS. – Complete Analysis of any Alloy, 25s.—L. PARRY, A.R.S.M., Union Bank Yard, Huddersfield. Speciality—Brasses, Bronzes, Anti-Friction Metals. 12 years' experience.

WANTED, for Brass Foundry, CRUCIBLE FURNACE for 80 lb. Crucibles.—Apply Box 576, Offices of THE FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.

STIGNIC PAINT.
NEWEST AND BEST WASH FOR STEEL FOUNDERS.
PLASTIC CUPOLA GANISTER.
FINEST MATERIAL FOR LINING CUPOLAS AND FURNACES AND SETTING FIRE-CLAY BRICKS.
SPECIAL **STEEL MOULDERS' COMPO.**
STEPHENS & CO., Kidwelly.

FOUNDRY EQUIPMENT.
PATENT CORE MAKING MACHINES
No linseed oil or flour required.
NEW PORTABLE MOULD DRIERS
Moulds dried on the spot in an hour to one hour and a half.
J. W. & C. J. **PHILLIPS,**
23, COLLEGE HILL, London, E.C.,
And 7, PARK SQUARE, LEEDS.

COLD BLAST PIG-IRON.

M. & W. GRAZEBROOK,
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BRUSHES,	CHAPLETS & STUDS,	LADLES,
BELLOWS,	CEMENT,	RIDDLES & SIEVES,
BUCKETS,	CORE GUM,	SPADES, SPRIGS,
BARROWS,	CORE ROPE,	TERRA FLAKE,
BLACKING,	CORE TAPER,	FERRO-ALUMINIUM,
COAL DUST.	CRUCIBLES,	ETC.
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MOOR & SONS, 1, Fennel St., **MANCHESTER,** (Dept. F.)
Established 1857. Telegrams "Acklam." Telephone, No. 3566.

BELT PULLEY MOULDING MACHINE.

For Single or
Double Arm Pulleys.

For Straight or
Curved Arm Pulleys.

For Split or
Solid Boss Pulleys.

USED BY
PULLEY
MAKERS,
MILLWRIGHTS,
MACHINISTS,
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Four sizes of **MACHINES** to make Pulleys from **4** in. to **60** in. dia., and from **12** in. to **30** in. face.

The London Emery Works Company, "Dept. C,"
Park, Tottenham, London, N.

Telephone No. 47 Heaton Moor.

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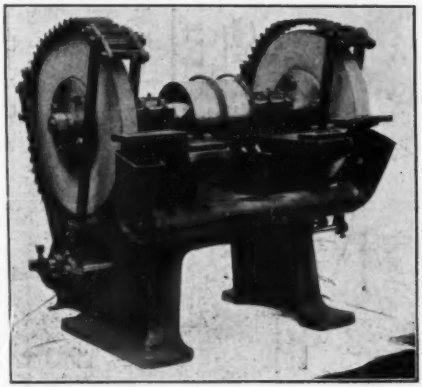
Telegraphic Address: "Heroic, Reddish."

Crystal Canadian Corundum,



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EMERY WHEELS,

For Foundry Use

ALSO

ALL CLASSES OF

GRINDING . .

MACHINES. . .

Send for Catalogue and Prices.

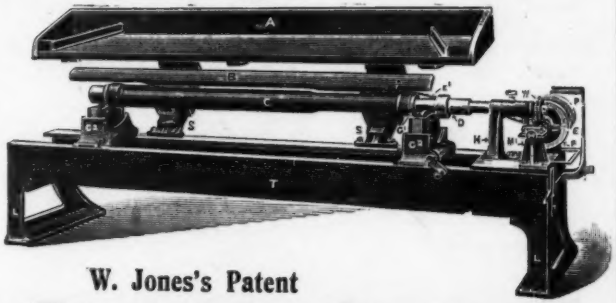
B. R. ROWLAND & CO., LTD.,

REDDISH, Near STOCKPORT.

A REVOLUTION IN

Pipe Foundry Practice

For Pipe Cores, 18 ft. long and 2 in. to 20 in. diameter.



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JONES & ATTWOOD,

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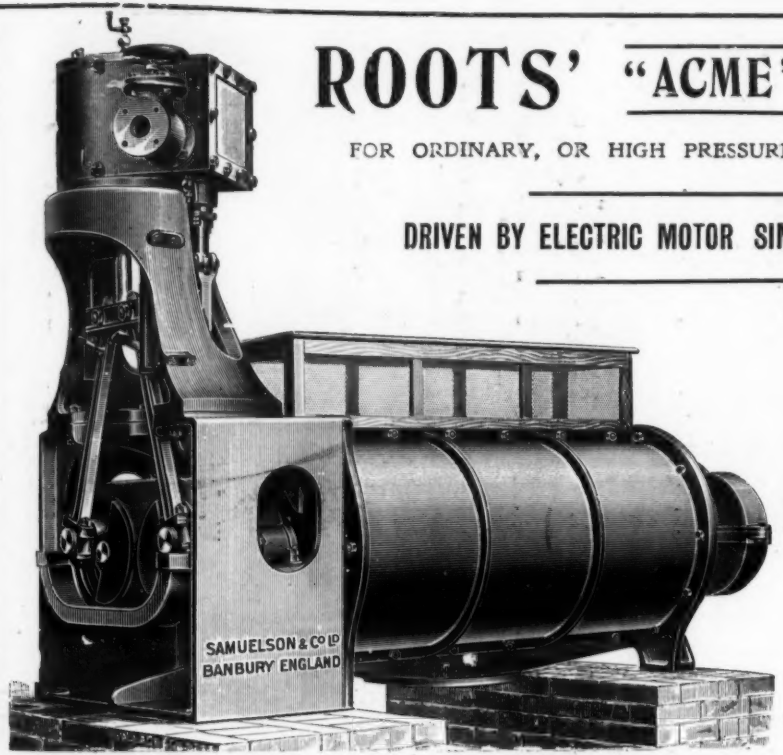
ROOTS' "ACME" BLOWERS

FOR ORDINARY, OR HIGH PRESSURES UP TO 10 LBS. PER SQ. IN.

DRIVEN BY ELECTRIC MOTOR SIMPLE OR COMPOUND ENGINE.



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FOUNDRY MOULDING MACHINES

For Economical Repetition Work.

Full Particulars from :—

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THE RAPID "ECONOMIC" CUPOLA.

CORE MACHINES (Rotary and Piston Types).

CORE STOVES (Hislop's System).

"LEEDS" HANDPRESS MOULDING MACHINES.

"LEEDS" COMBINATION (Hand Press and Turn-over) MOULDING MACHINE.

PORTABLE MOULD DRIERS.

SAND MILLS. FOUNDRY SUNDRIES.

Write for Catalogue to

HORACE P. MARSHALL & CO., LEEDS.

CUPOLA LININGS of "Black Delph" Firebricks

combine great refractoriness with high resistance to abrasion.

E. J. & J. PEARSON, Ltd., STOURBRIDGE.

WHY BUY NEW CUPOLAS?

When you can have old ones converted, at small cost, by introducing

HIGHAM'S HOT BLAST PROCESS.

A Saving is effected in Coke of at least 25% on small furnaces.

I will adapt existing Cupolas to my process, allow a month's free trial, and if any dissatisfaction be expressed at the results, restore the cupolas to their former condition.

JAMES HIGHAM, Iron Founder,

BROOM LANE, LEVENSHULME, MANCHESTER.

FIRST CLASS PATTERN PLATES

are now being made by moulders in foundries, with

WHITE'S PATTERN PLATE APPARATUS

without the aid of any expensive machine tools.

No method of making repetition work in foundries **is complete without** a simple ready system of making pattern plates as required for either hand or machine moulding.

White's system completely meets these requirements. Write for illustrated pamphlet, to

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ON ADMIRALTY LIST. London Office: W. Littleton, 9, Fenchurch Street, E.C.

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BLACKINGS

(Iron Moulders).

COAL DUST and other Foundry Requisites.

THOMAS WILKINSON & CO., LTD., MIDDLESBROUGH.

CHAS. HALL,

Foundry Requisite Maker,

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STEEL WIRE BRUSHES.

Chaplets and Studs a Speciality.

COLD BLAST PIG-IRON.

M. & W. GRAZEBROOK,
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FOUNDRY REQUISITES.

BRUSHES,	CHAPLETS & STUDS,	LADLES,
BELLOWS,	CEMENT,	RIDDLES & SIEVES,
BUCKETS,	CORE GUM,	SPADES, SPRIGS,
BARROWS,	CORE ROPE,	TERRA FLAKE,
BLACKING,	CORE TAPER,	FERRO-ALUMINIUM,
COAL DUST.	CRUCIBLES,	ETC.
	CUPOLAS,	

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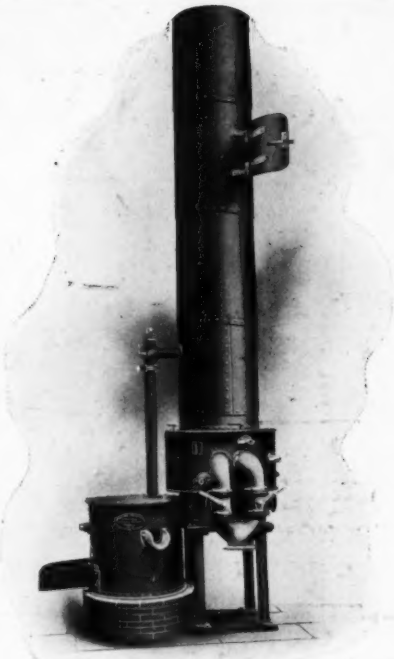

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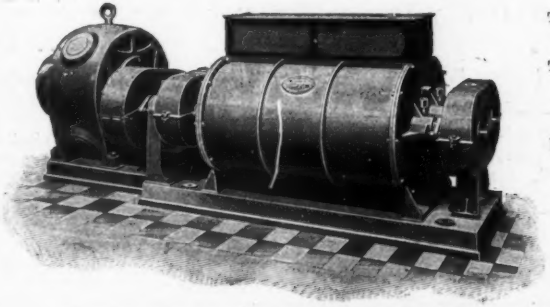

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